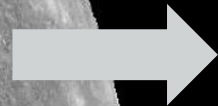
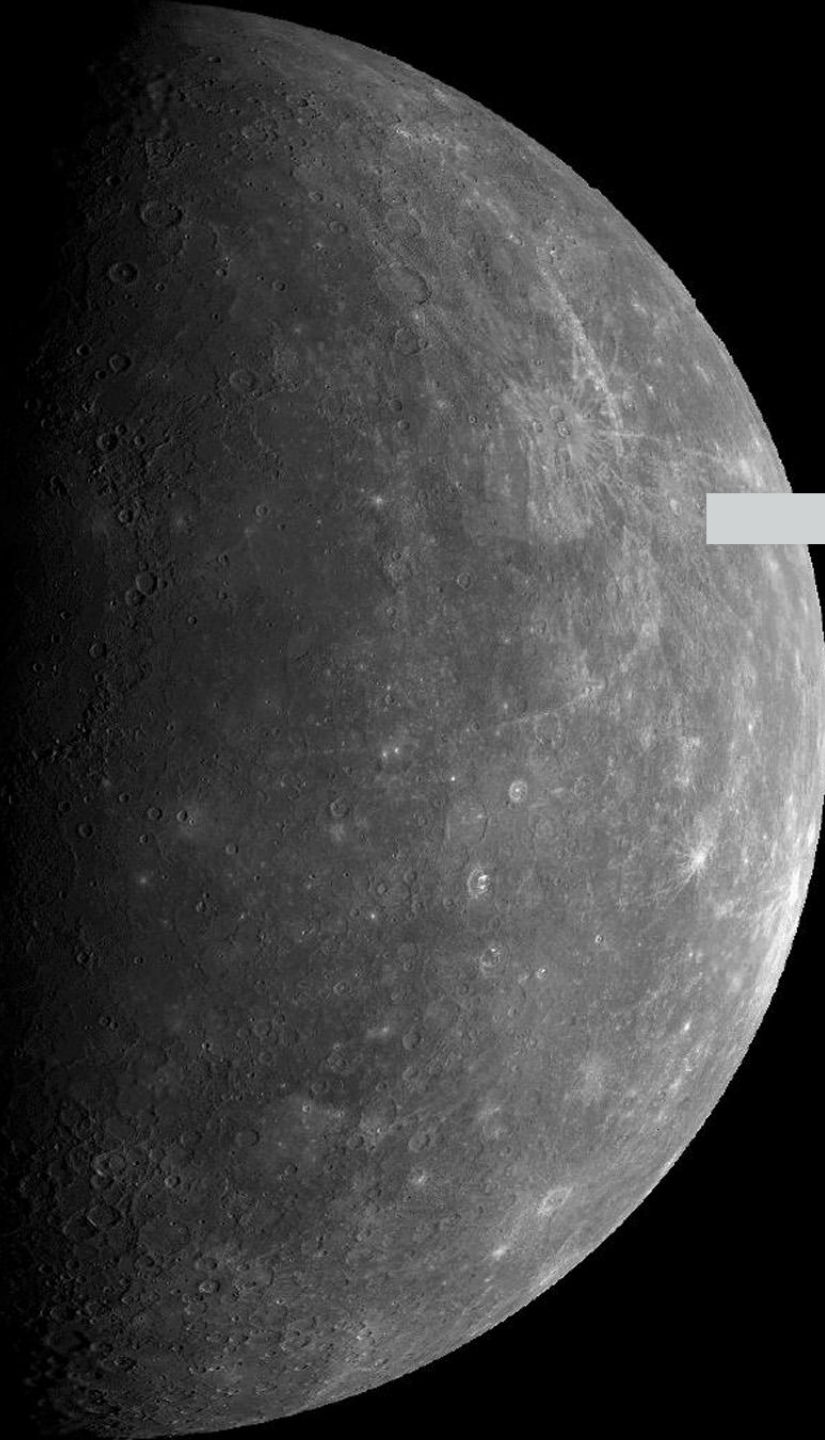


The OpenSE Cookbook: A practical, recipe based collection of patterns, procedures, and best practices for executable systems engineering for the Thirty Meter Telescope

***Robert Karban, CAE Project Systems Engineer
Jet Propulsion Laboratory,
California Institute of Technology***

18-22 June 2018 – OMG Technical Meeting, Boston, MA, USA

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Agenda

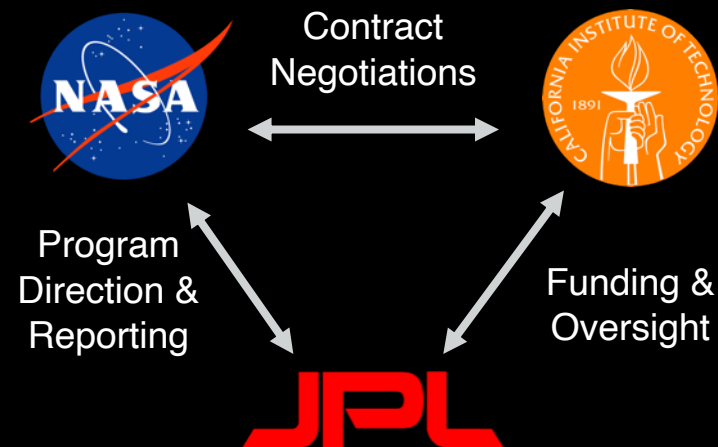
- Introduction
- TMT and MBSE Approach
- Cookbook Principles
- Selected Cookbook Patterns



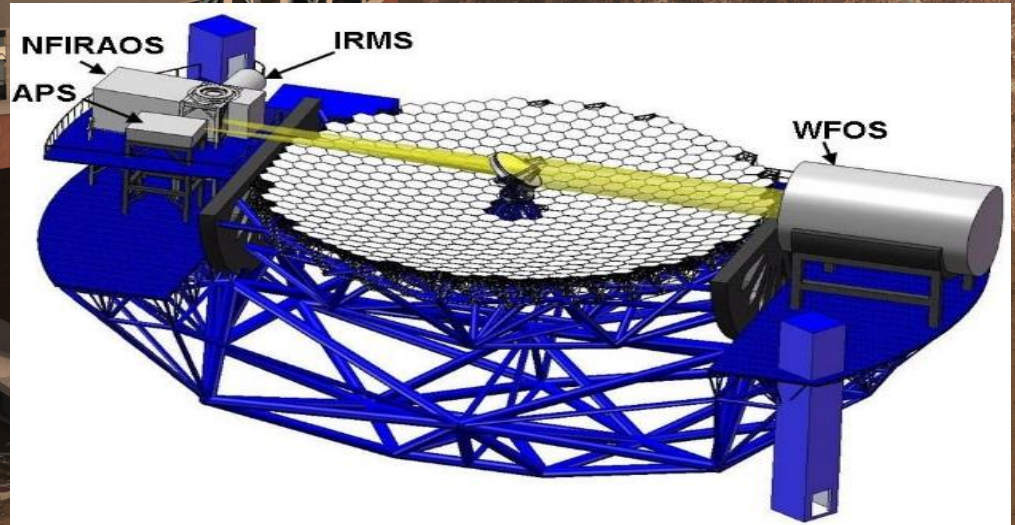
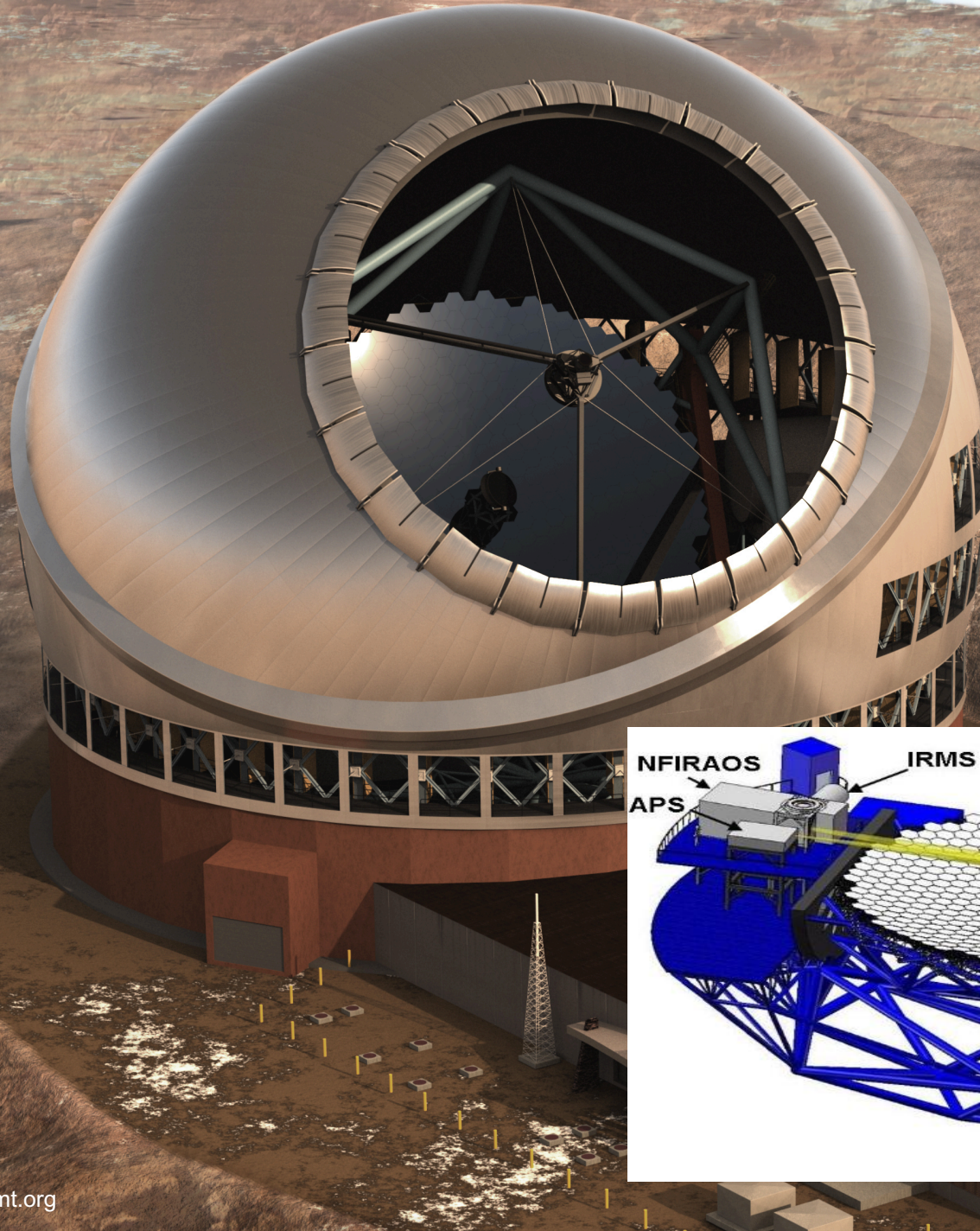
NASA Jet Propulsion Laboratory (JPL)



- Located in Pasadena, CA
- NASA-owned *"Federally-Funded Research and Development Center"*
- University-operated
- ~5,000 employees

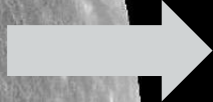


The Thirty Meter Telescope (TMT) Project





Agenda

- 
- Introduction
 - TMT and MBSE Approach
 - Cookbook Principles
 - Selected Cookbook Patterns



Jet Propulsion Laboratory
California Institute of Technology

TMT applies “Hybrid” Systems Engineering Approach

Traditional SE

- Clear, defined deliverables
- Easily accessible
- Shallow learning curve
- Simple traceability

MBSE

- Understanding behaviors of a system
- “Rich” capability to represent complex systems

Exploit the advantages of each approach

TMT MBSE Approach delivers consistent, verifiable engineering products

- Define an **executable SysML model**
- Use the model to **analyze the system design and verify requirements** on power consumption, mass, duration, pointing errors, etc.
- Produce **engineering documents**
 - Requirement Flow Down Document
 - Operational Scenario Document
 - Design Description Document
 - Interface Control Documents
- Use **standard languages and techniques, and COTS tools where practical** to avoid custom software development

TMT MBSE follows a well defined Modeling Approach

- Object-Oriented Systems Engineering Method (**OOSEM**), but with additional activities focusing on building an executable model
- Use case driven model development
- Challenges:
 - JPL is a **supplier** for a number of subsystems of the TMT (the **customer**)
 - Model is used by a number of teams, including TMT


ESEM = OOSEM + Executability

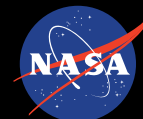
Systems Model is developed according to ESEM using Cookbook Patterns

- Define APS Mission boundaries
- Elaborate Conceptual Architecture
- Capture Component Behavior and Characteristics
- Specify Interactions between Components
- Run Analyses



Agenda

- 
- Introduction
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OpenSE Cookbook addresses Systems Engineering Concerns

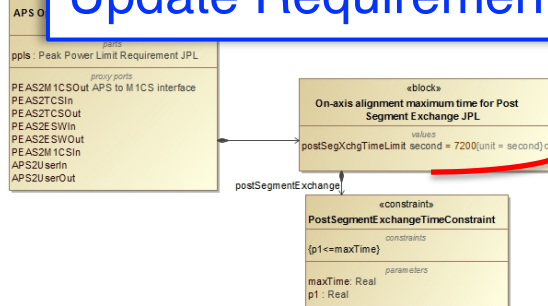
- Provides goal oriented guidance using patterns, e.g.
 - How-to Verify Requirements
 - How-to Roll-up Technical Resources
- Driven by Systems Engineering Workflows
- Enables combining patterns into more complex recipes
- Demonstrates how to build system models with available tooling - How/where do I start?
- Includes known usages in TMT production model as reference
- Commoditizes Executable Systems Engineering

OpenSE Cookbook combines different aspects

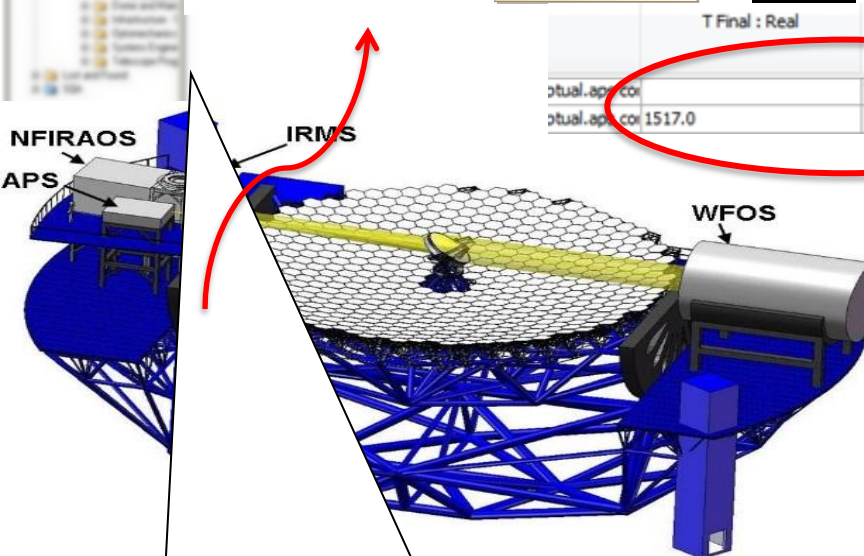
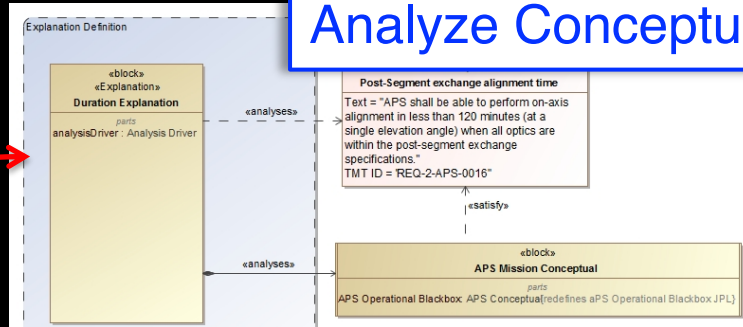
- Update 2012 “Cookbook for MBSE with SysML”
 - Focus on structure and requirements using European FP7 Active Phasing Experiment (APE) as case study
- Include Patterns developed for TMT
 - Focus on behavior and analysis workflows
- Guided by ESEM methodology
- Describe tooling support provided by JPL Systems Environment
- OpenSE model library provides commonly used elements
- Instructional examples
- Application to actual engineering team, i.e. TMT
- Template Models and recommended model organizations

TMT Analysis workflows drive the OpenSE Cookbook

Update Requirements 2



Analyze Conceptual Design 3



	T Final : Real	Post Seg Xchg Time Limit : Second	Post Segment Exchange : Post Segment Exchange Time Constraint	Off Axis Measurement Steps : Integer	Off Axis Map Points : Integer	RB Dit : Integer	Phasing Dit : Integer
actual.ap.col	1517.0	7200.0	Pass	6	7	45	20

Analyze Realization Design/Specification 4

#	Name	Classifier	Operating Power : W	Standby Power : W
1	peak Power Limit Scenario Online APS Realization	APS Realization	0.0	0.0
2	peak Power Limit Scenario Online APS Realization done Installation	Dome Installation	0.0	0.0
3	peak Power Limit Scenario Online APS Realization done Installation Ins	Instrument	0.0	0.0
4	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack	Controller Rack	0.0	0.0
5	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower	Motor Ctl	0.0	0.0
6	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower	Power/Filter/Pattern	0.0	0.0
7	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower	Camera Ctl	150.0	200.0
8	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
9	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
10	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
11	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
12	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
13	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
14	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
15	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			
16	peak Power Limit Scenario Online APS Realization done Installation Ins.electronics rack subPower			

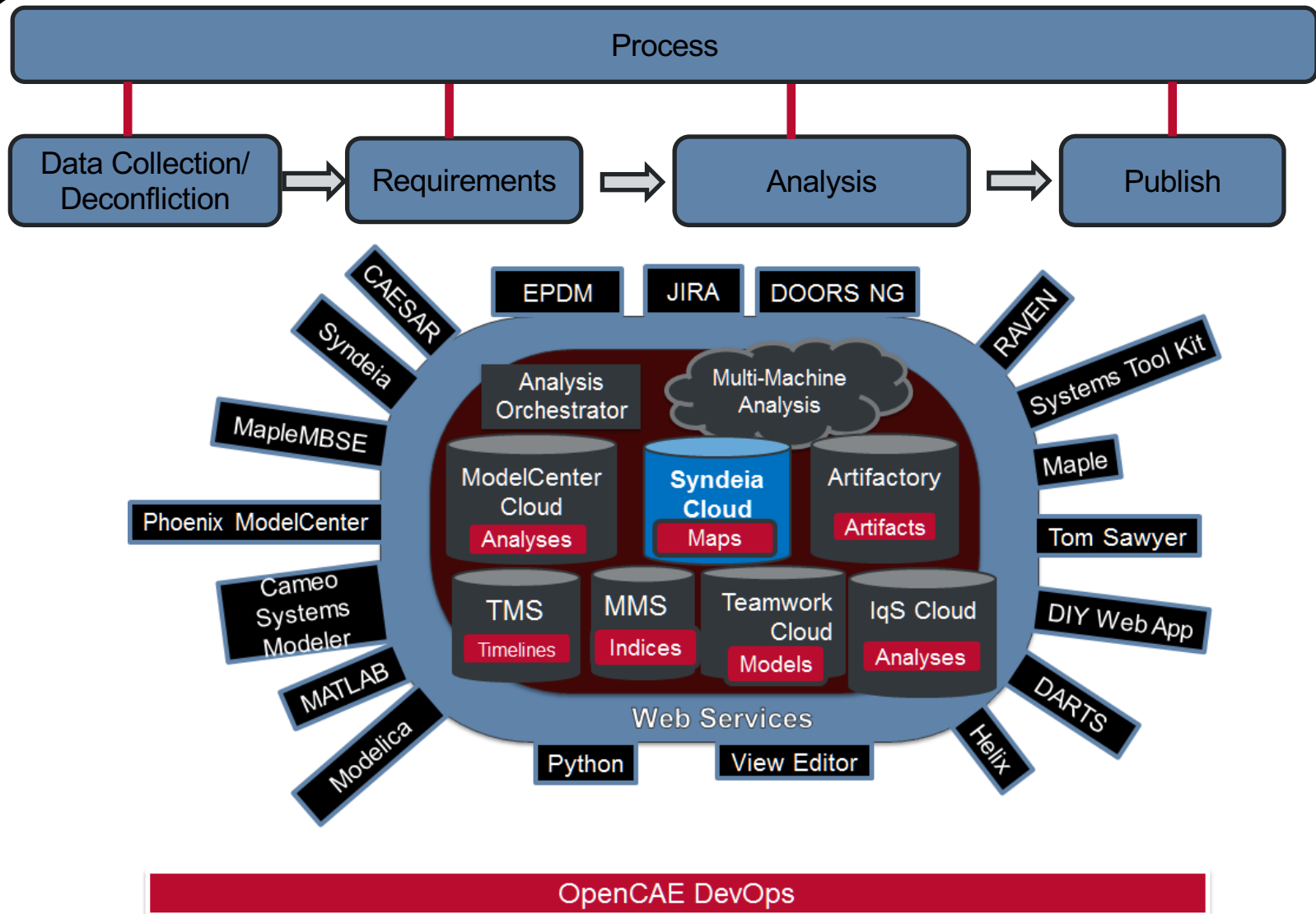
Pass/fail

Change request 1

Max duration Post-segment exchange: 7200s 5000s
 Number of exposures of 45s 4 6
 Max peak power consumption in dome: 8.5kw 8.1kw
 Number of motors with 50W 10 12

Produce Engineering Documents 5

JPL/CAE Systems Environment provides integrated Life-Cycle Support



JPL develops requirements for Systems Environment (tooling) through Case Studies

For Example:

- Requirements Management
- Interface Management
- Design Management
- Trade Studies
- Interdisciplinary Integration
- Analysis Pipeline
- Resource Management
- Timeline Management

Using tools from OpenMBEE community

Open Model Based Engineering Environment

- OpenMBEE is a community for open-source modeling software and models
 - Open source software
 - MMS, ViewEditor, MDK
 - Open source models
 - TMT, OpenSE Cookbook
- JPL is a participant and adopter of OpenMBEE software and models
- Boeing, Lockheed, OMG, NavAir, Ford, Stevens, GaTech, ESO, TMT, NASA
- Vendors participate as well
- ~200 members, annual INCOSE workshop
- www.openmbee.org

Pattern Structure

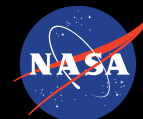
Every pattern follows the same structure

- Intent
- Motivation
- Concept
- Consequences
- Implementation
- Known Uses
- Tooling
- Related Patterns



Agenda

- Introduction
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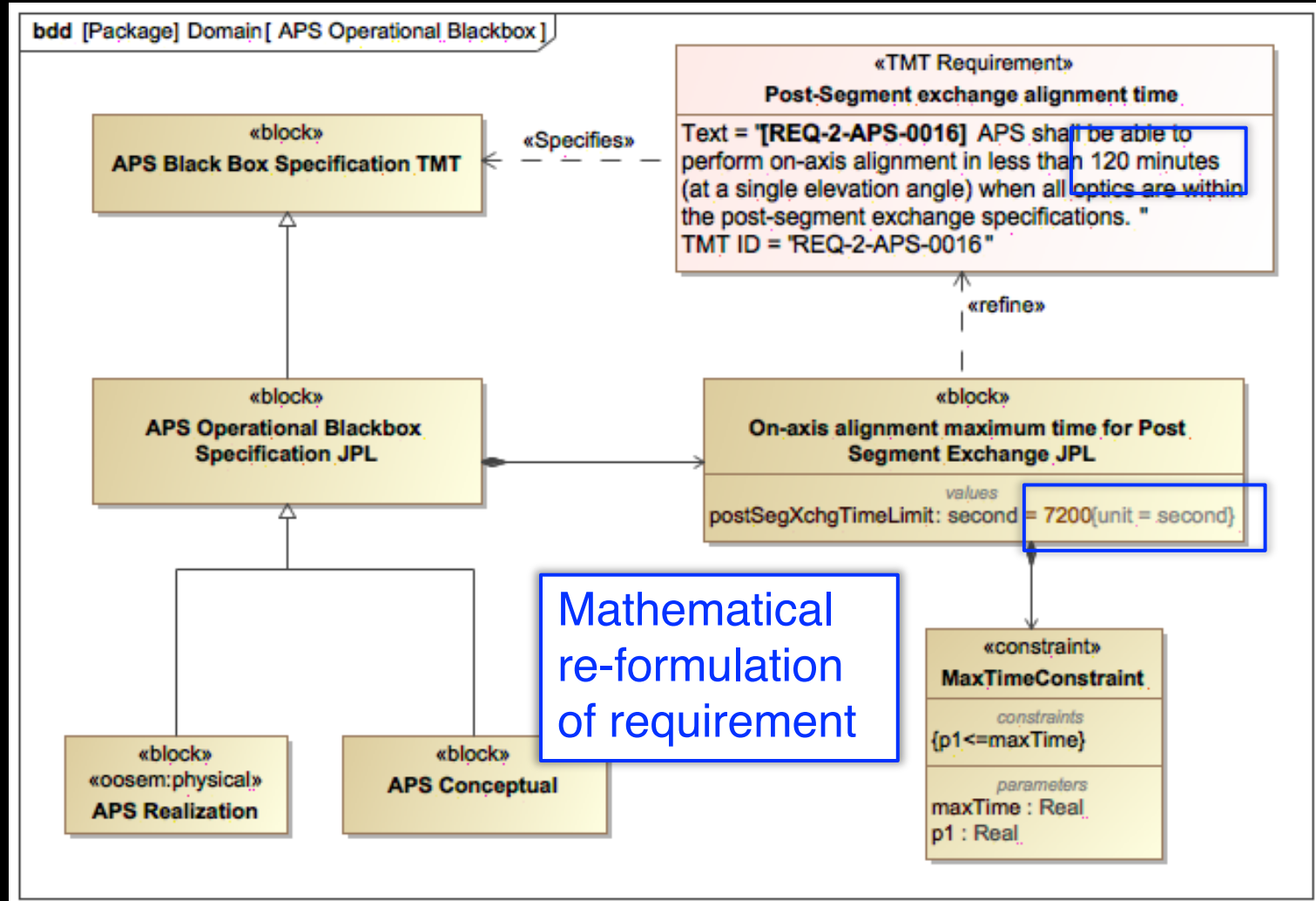


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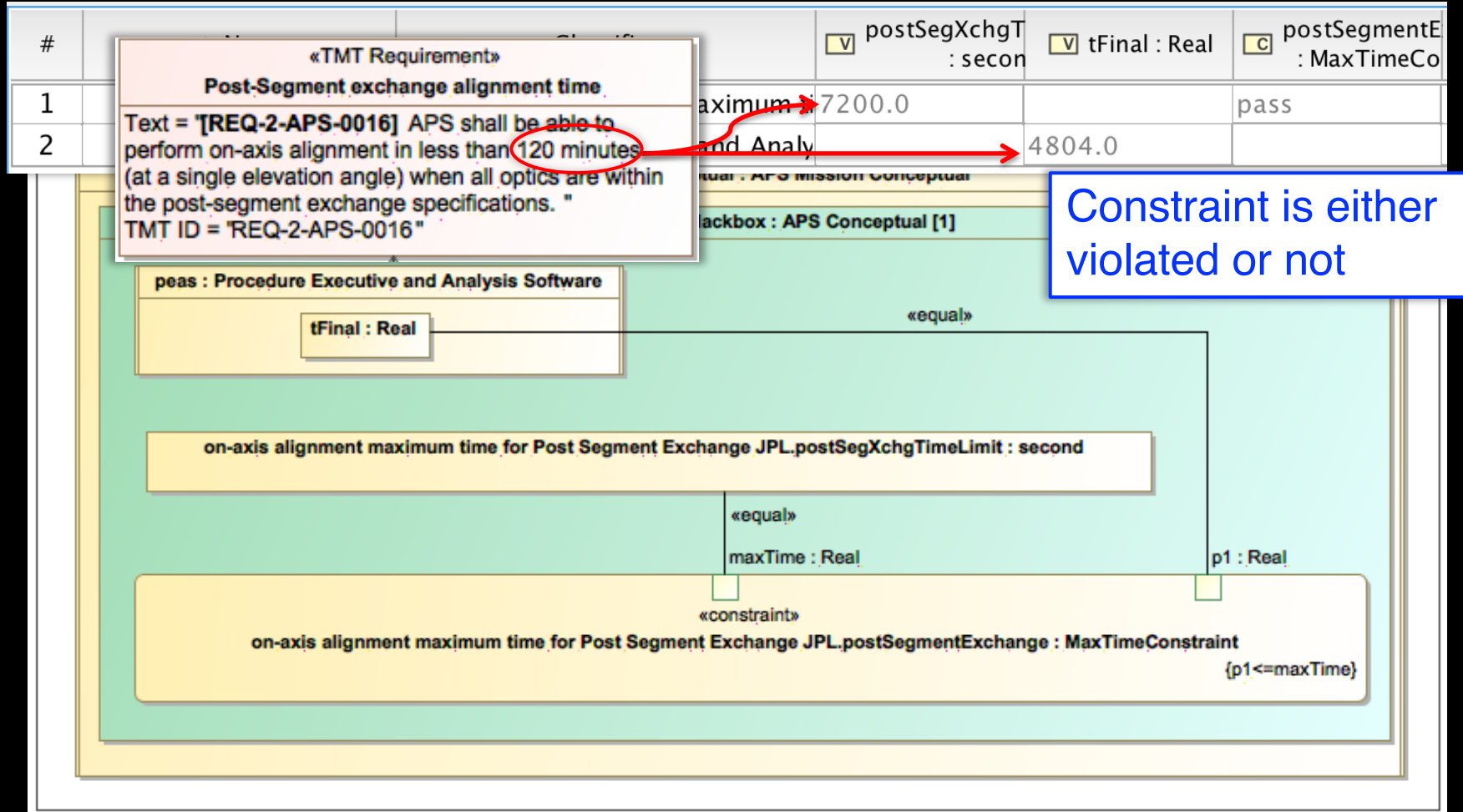
Requirements Verification

- Intent
 - Validate requirements, verify as designed system against requirements and publish analysis results
- Cookbook Volume
 - System Requirements Management
- Educational example
 - Autonomous Ferry Transportation
- Known Uses
 - APS - Post-segment exchange timing requirements
- Tooling
 - Cameo Systems Modeler and Simulation Toolkit, View Editor
- Notes
 - Property Based Requirements links Requirements Management and System Design

Formalizing Requirements with Property Based requirements



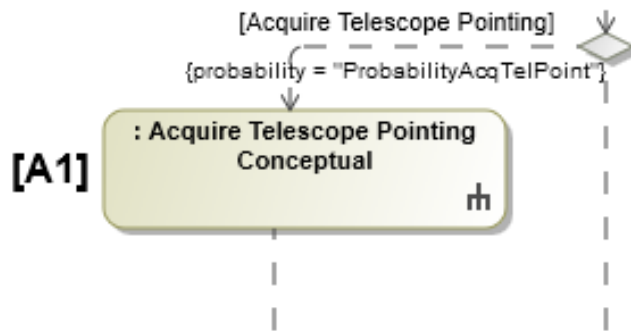
Verifying Timing Requirements by Simulation



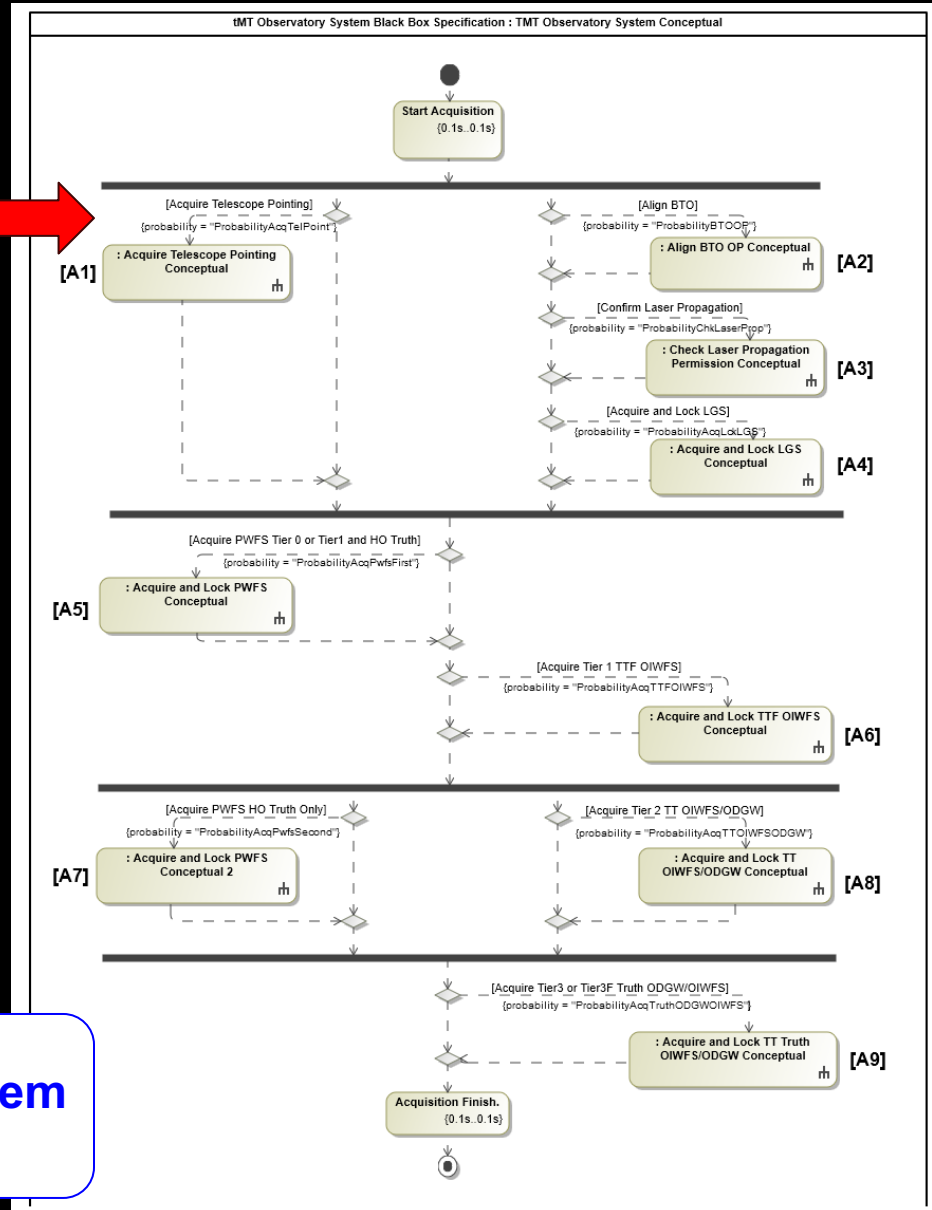
Monte Carlo Driven Analysis

- Intent
 - Estimate the characteristics and probability of a particular behavior using modeling anchored through data.
- Cookbook Volume
 - System Analysis Management
- Educational example
 - Quadrupedal Robot
- Known Uses
 - AO - Acquire a target with IRIS and NFIRAOS
- Tooling
 - Cameo Systems Modeler and Simulation Toolkit, View Editor
- Notes
 - SysML probability concepts and distributed properties capture operational knowledge in system model

Behavior with Probabilities



TMT Observatory System
Conceptual



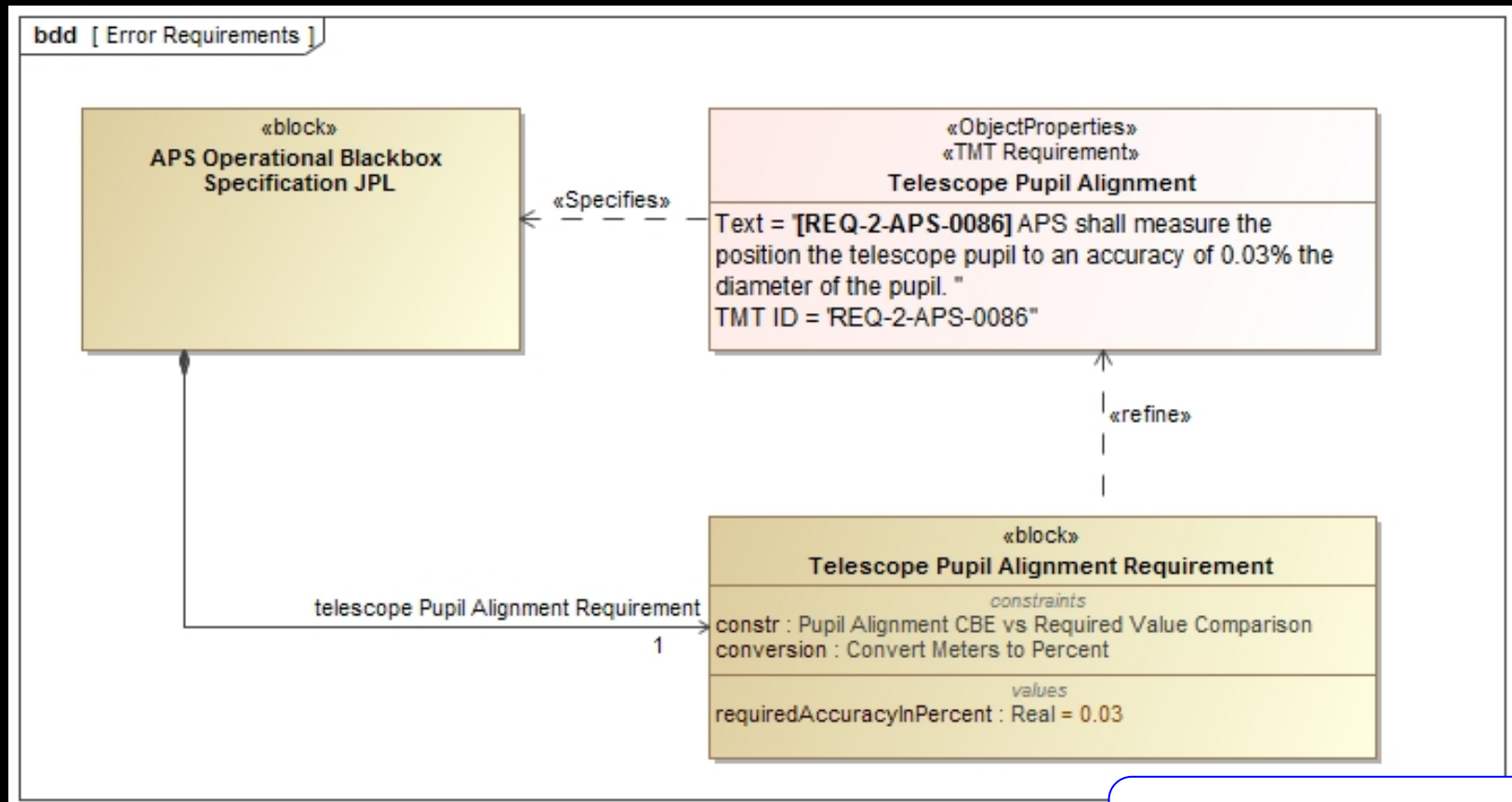


Resulting Trace

Error Budget Management

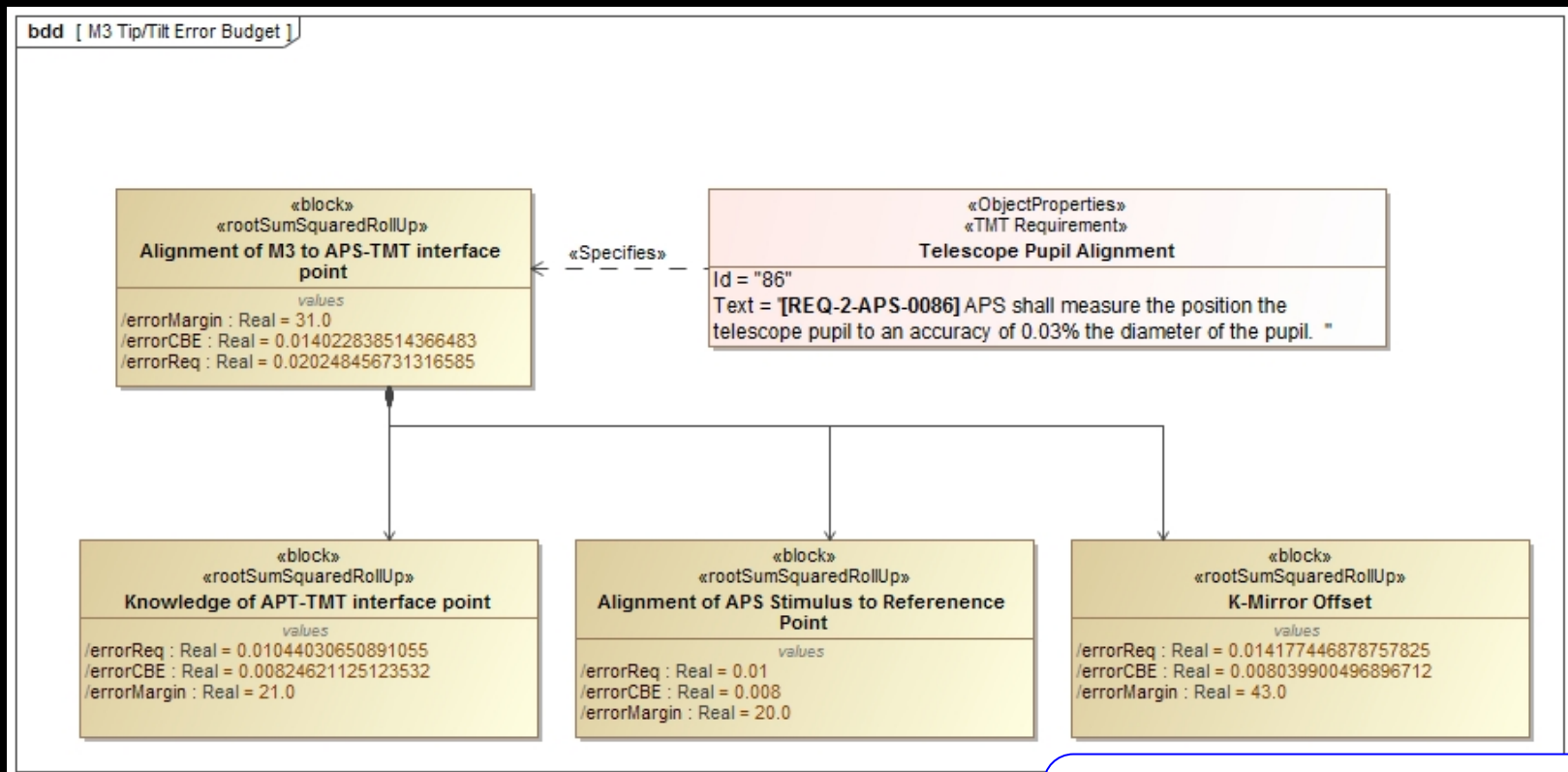
- Intent
 - Manage error budgets of technical resources such as wave front error
- Cookbook Volume
 - System Resource Management
- Educational example
 - Microscope
- Known Uses
 - APS - Alignment error of the M3 to APS interface
- Tooling
 - Cameo Systems Modeler and Simulation Toolkit, View Editor

APS - Alignment error of the M3 to APS interface



Context

Specify RSS Tree



Application of pattern

Conclusions and Summary

- OpenSE Cookbook addresses SE concerns, activities, and processes
- Built on proven patterns from TMT and APE
- Supported by tooling
- Open for contributions and collaboration through INCOSE Telescope Challenge team

Accessible at

<https://mms.openmbee.org>

Acknowledgements

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

The TMT Project gratefully acknowledges the support of the TMT collaborating institutions. They are the Association of Canadian Universities for Research in Astronomy (ACURA), the California Institute of Technology, the University of California, the National Astronomical Observatory of Japan, the National Astronomical Observatories of China and their consortium partners, and the Department of Science and Technology of India and their supported institutes. This work was supported as well by the Gordon and Betty Moore Foundation, the Canada Foundation for Innovation, the Ontario Ministry of Research and Innovation, the National Research Council of Canada, the Natural Sciences and Engineering Research Council of Canada, the British Columbia Knowledge Development Fund, the Association of Universities for Research in Astronomy (AURA) and the U.S. National Science Foundation.

References

- OpenSE Cookbook: https://mms.openmbee.org/alfresco/mmsapp/mms.html#/projects/PROJECT-ID_2_2_17_7_33_25_AM_3ccfaf88_159fe0d7ba9_7d4e_cae_tw_jpl_nasa_gov_127_0_0_1/master/document/18_5_2_e64033a_1513276256458_934885_22190
- INCOSE SE2 Cookbook: <https://mbse.gfse.de/documents/faq.html>
- Karban, R., Jankevičius, N., Elaasar, M. “ESEM: Automated Systems Analysis using Executable SysML Modeling Patterns”, (to appear in the proceedings of INCOSE International Symposium (IS), Edinburgh, Scotland, 2016.)
- Karban R., Dekens F., Herzig S., Elaasar M, Jankevičius N., “Creating systems engineering products with executable models in a model-based engineering environment”, SPIE, Edinburgh, Scotland, 2016
- Karban, R., “Using Executable SysML Models to Generate Systems Engineering Products”, NoMagic World Symposium, Allen, TX, 2016
- Open Source TMT model: <https://github.com/Open-MBEE/TMT-SysML-Model>
- Open Source Engineering Environment: <https://www.openmbee.org>
- Docgen, ViewEditor, MMS: <https://github.com/Open-MBEE/open-mbee.github.io/wiki/OpenMBEE-documentation>
- JPL Model-Based Systems Engineering Case Study:
http://omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:incose_mbse_iw_2017:iw_2017_open_mbee.pdf
- A Practical Guide to SysML, 3rd Edition, Chapter 17 by Friedenthal, Moore, and Steiner
- <https://www.jpl.nasa.gov/spaceimages/>
- INCOSE Telescope Challenge Team, <http://omgwiki.org/MBSE/doku.php?id=mbse:telescope>

The background of the slide is a cosmic scene. On the left, a black hole is depicted with a bright, glowing accretion disk in shades of purple, pink, and blue. To the right, a bright star or galaxy core emits a powerful purple beam of light that stretches across the dark, star-filled space. The overall color palette is dominated by deep blues, purples, and pinks, creating a dramatic and ethereal atmosphere.

BACKUP SLIDES

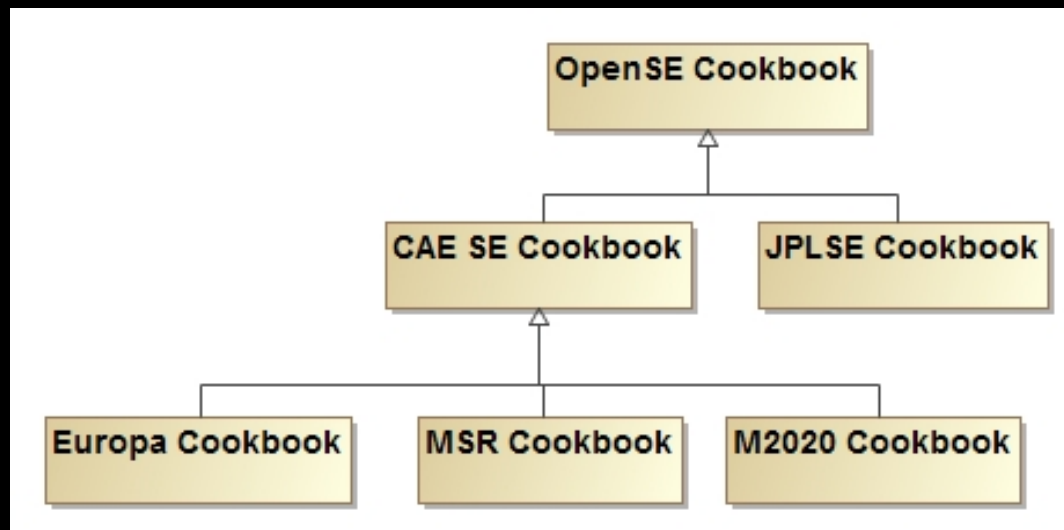
Who is Robert?



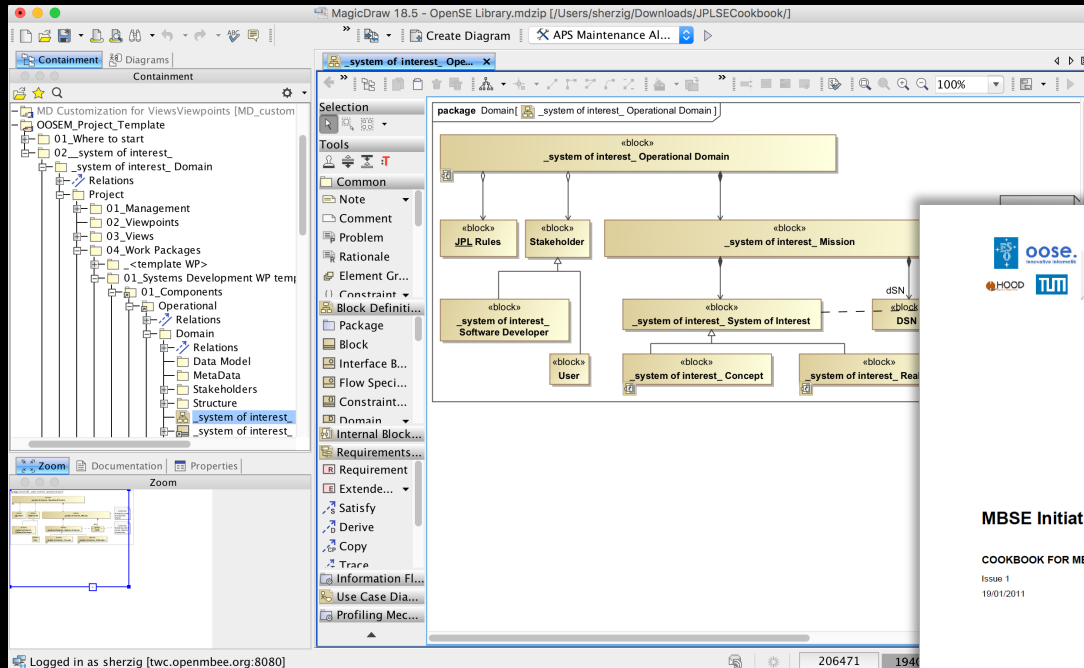
- CAE Project Systems Engineer at NASA's JPL - USA
- Member of INCOSE
- Co-Chair of the OMG SysML Revision Task Force
- Formerly Control System/Software Engineer and Architect at:
 - European Southern Observatory – Germany, Chile
 - CERN – Switzerland/France
 - Siemens Healthcare - Austria
- M.Sc. Computer Science (Austria)

OpenSE Cookbook promotes re-use

- OpenSE Cookbook contributes to JPL institutional and project specific Cookbooks
- Project-independent modeling patterns as guidelines
- Project-specific modeling patterns for common modeling tasks



OpenSE Cookbook and Template Model



“Cookbook” for modeling methodology & patterns

MBSE Initiative – SE2 Challenge

COOKBOOK FOR MBSE WITH SYSML

Issue 1
19/01/2011

SE2 Cookbook for MBSE with SysML

comprehensive product tree may in theory be satisfied by automatically merging all existing product tree diagrams into a big one (remember, each sub-system contains recursively its product tree).

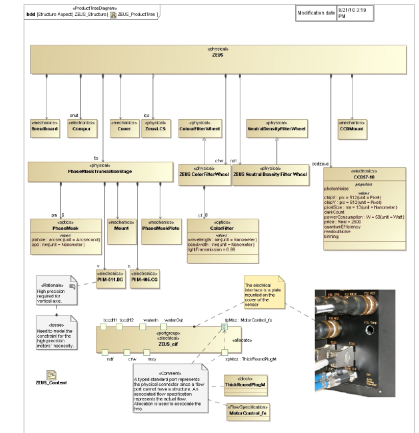


Figure 5 Product Tree of the ZEUS subsystem

ZEUS is one of the evaluated phasing sensors (Figure 5) and is based on the modified Michelson interferometer phasing sensor. It is mounted on a breadboard and consists of a shutter, a cover, a color filter wheel, a neutral density filter wheel, and a translation stage which carries a phase mask. Different phase masks can be moved to the focal position by means of a translation stage, able to move in the X and Y directions.

The two filter wheels located after the phase mask translation stage:

- A neutral Density Filter wheel: a set of 8 different neutral density filters are available
- An optical filter wheel: a set of 8 different optical filters centered on different wavelengths and with different bandwidths are available

Template models to be used by projects as a starting point, with recommended organization, model libraries, etc.

OpenSE Cookbook is used as reference

- OpenSE cookbook and TMT model used as reference model for the OMG SysML 2 standard
 - Demonstrate how SysML 2 will improve, simplify, change model wrt SysML 1.x
- Training material and knowledge transfer
- Promote standards and conventions
- Used by vendors as reference to test and evolve products

Define APS Mission boundaries

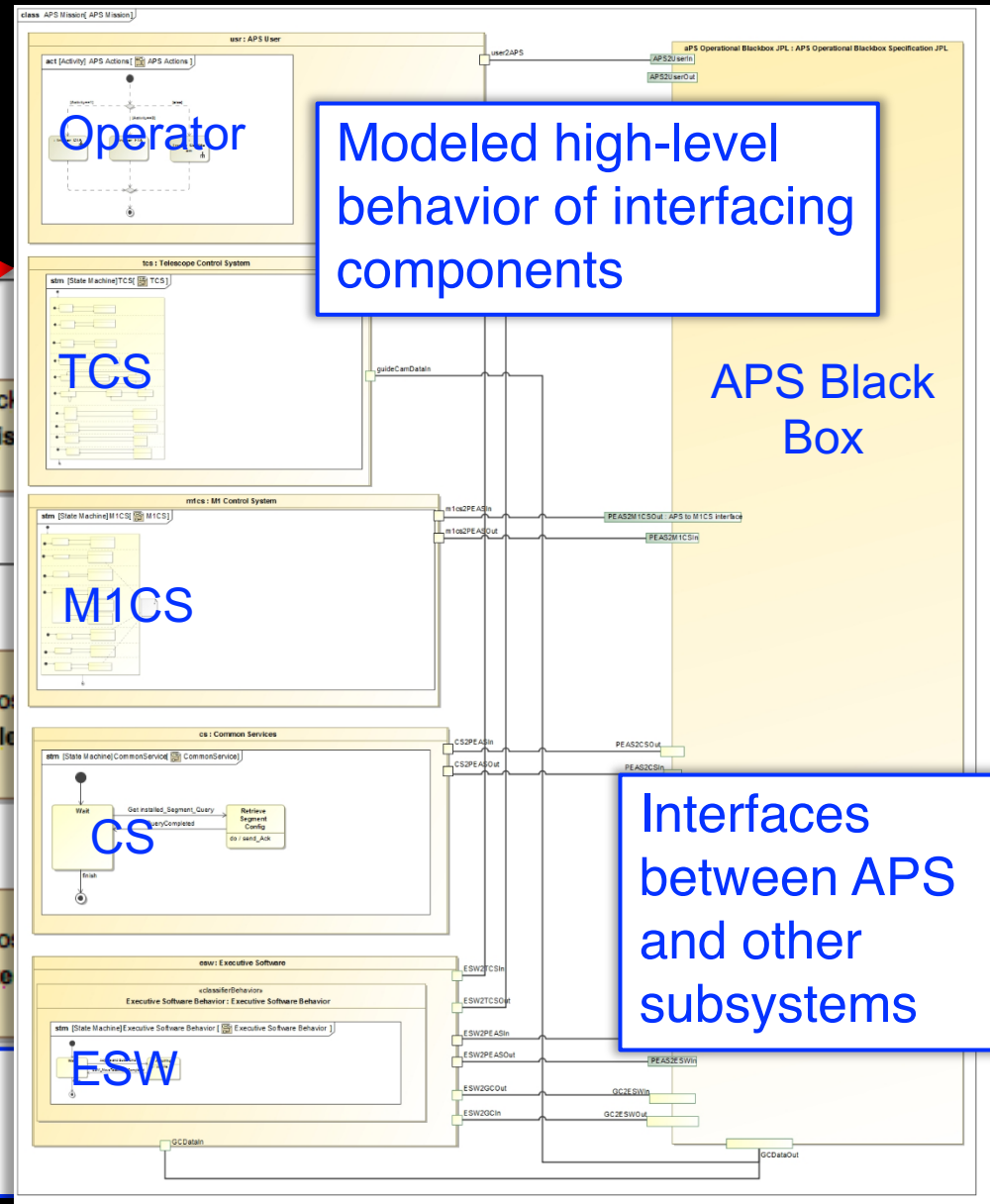
TMT specification handed to JPL

«block»
APS Black Box Specification TMT

«block»
APS Operational Blackbox Specification JPL

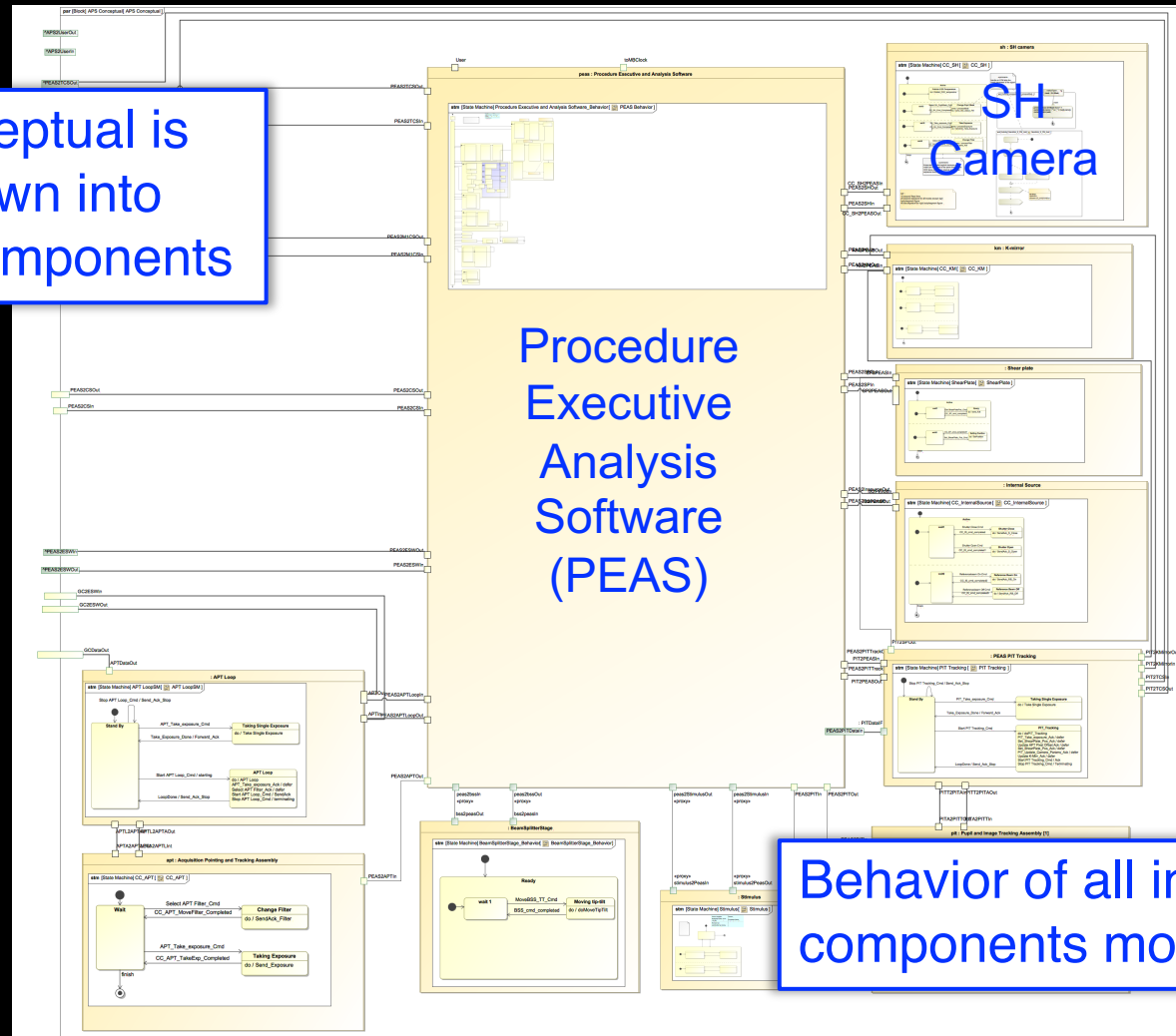
JPL realization of APS

Other TMT Subsystems



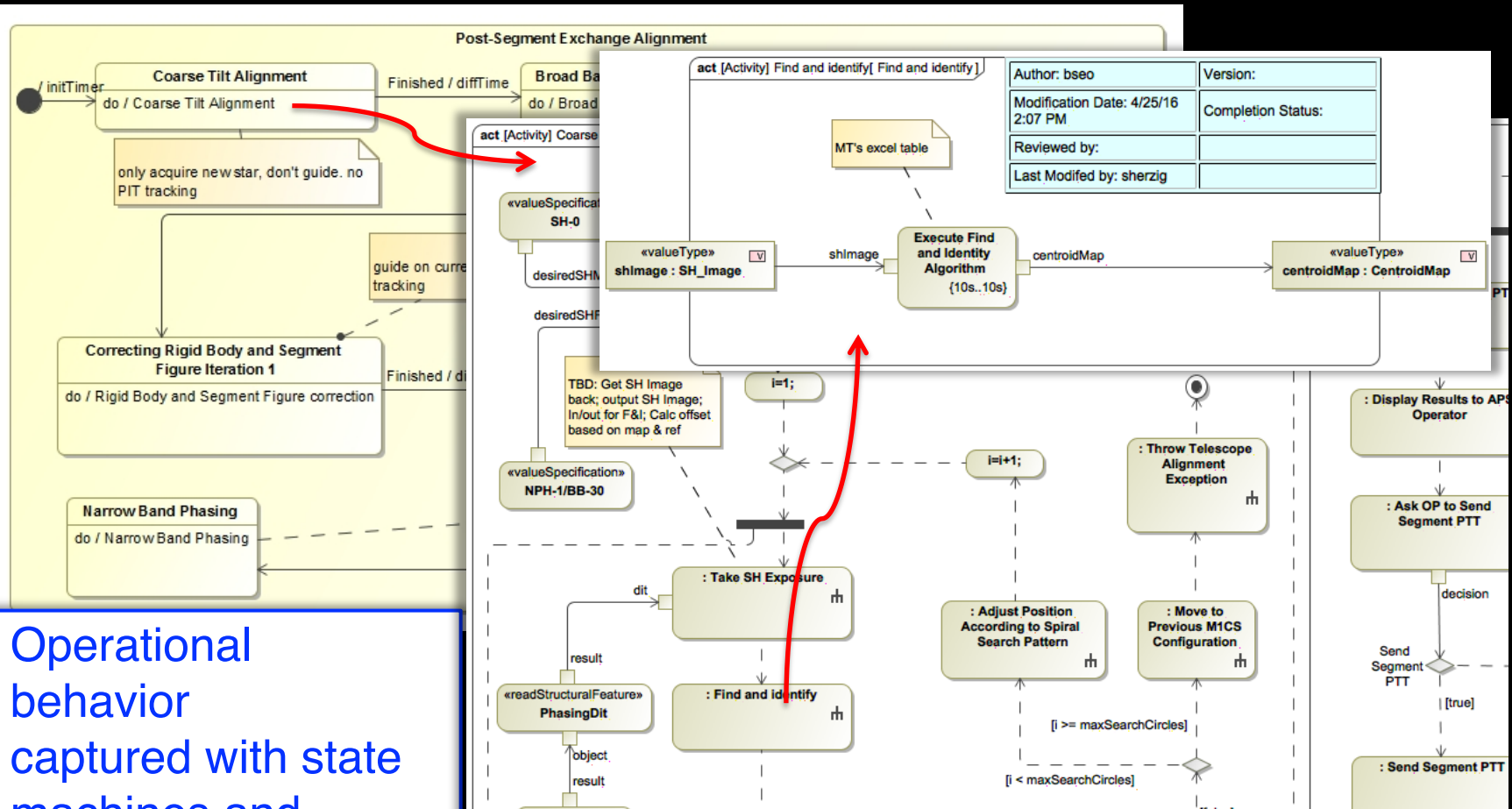
Elaborate Conceptual Architecture

APS conceptual is broken down into several components



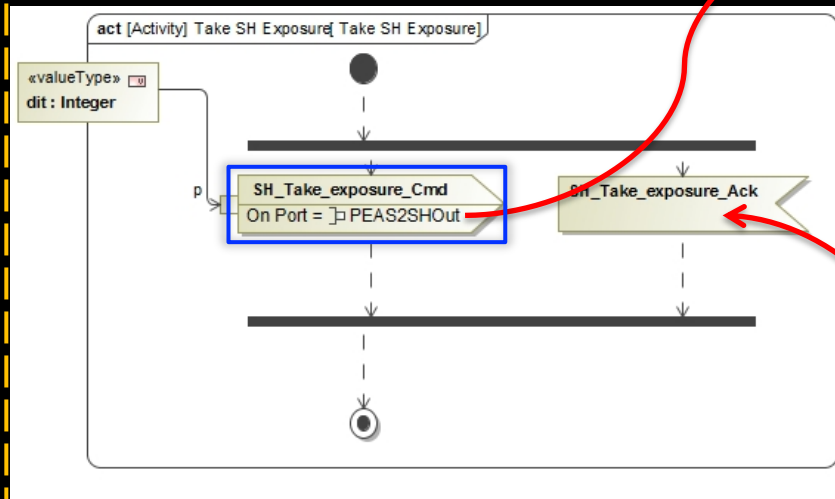
Behavior of all interacting components modeled

Operational
behavior
captured with state
machines and
activity models



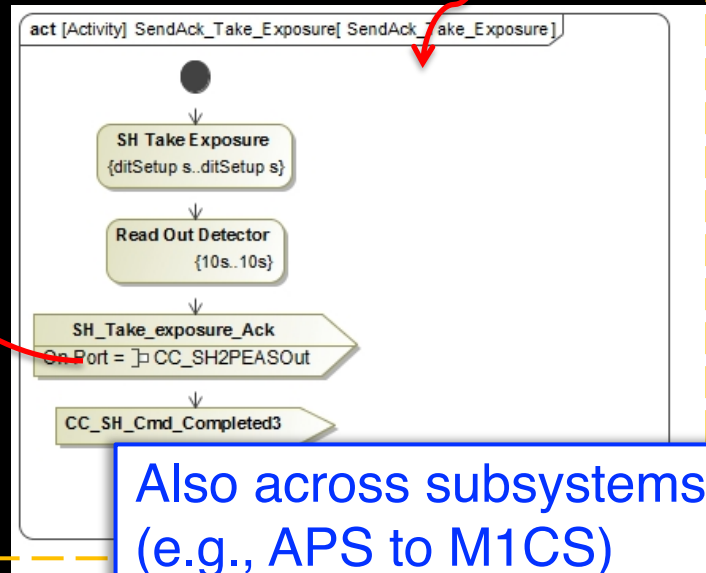
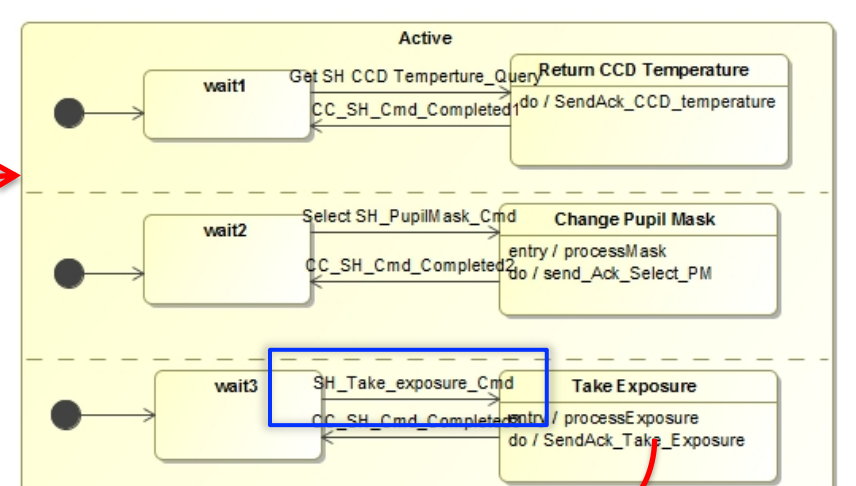
Specify Interactions Between Components

PEAS Context



Use of signals sent over ports to simulate a message passing mechanism between components

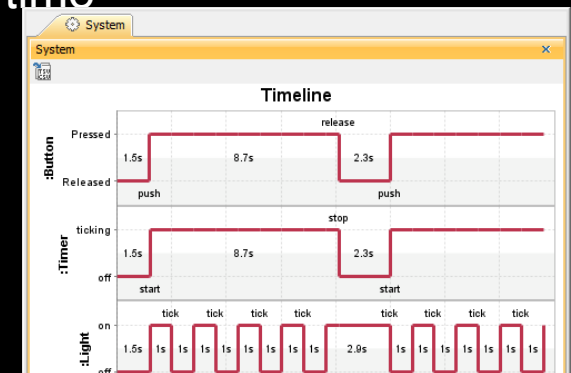
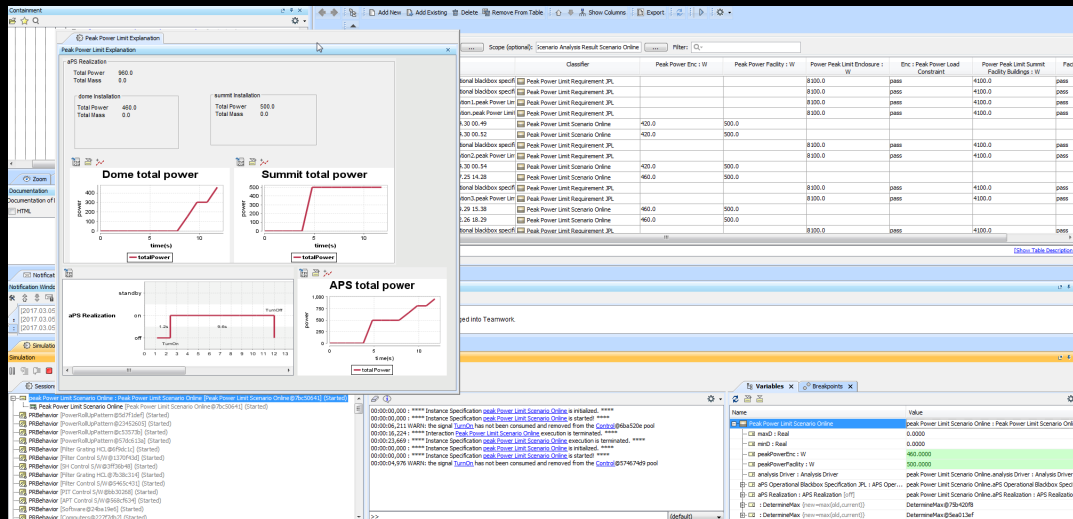
SH Camera Context



Also across subsystems!
(e.g., APS to M1CS)

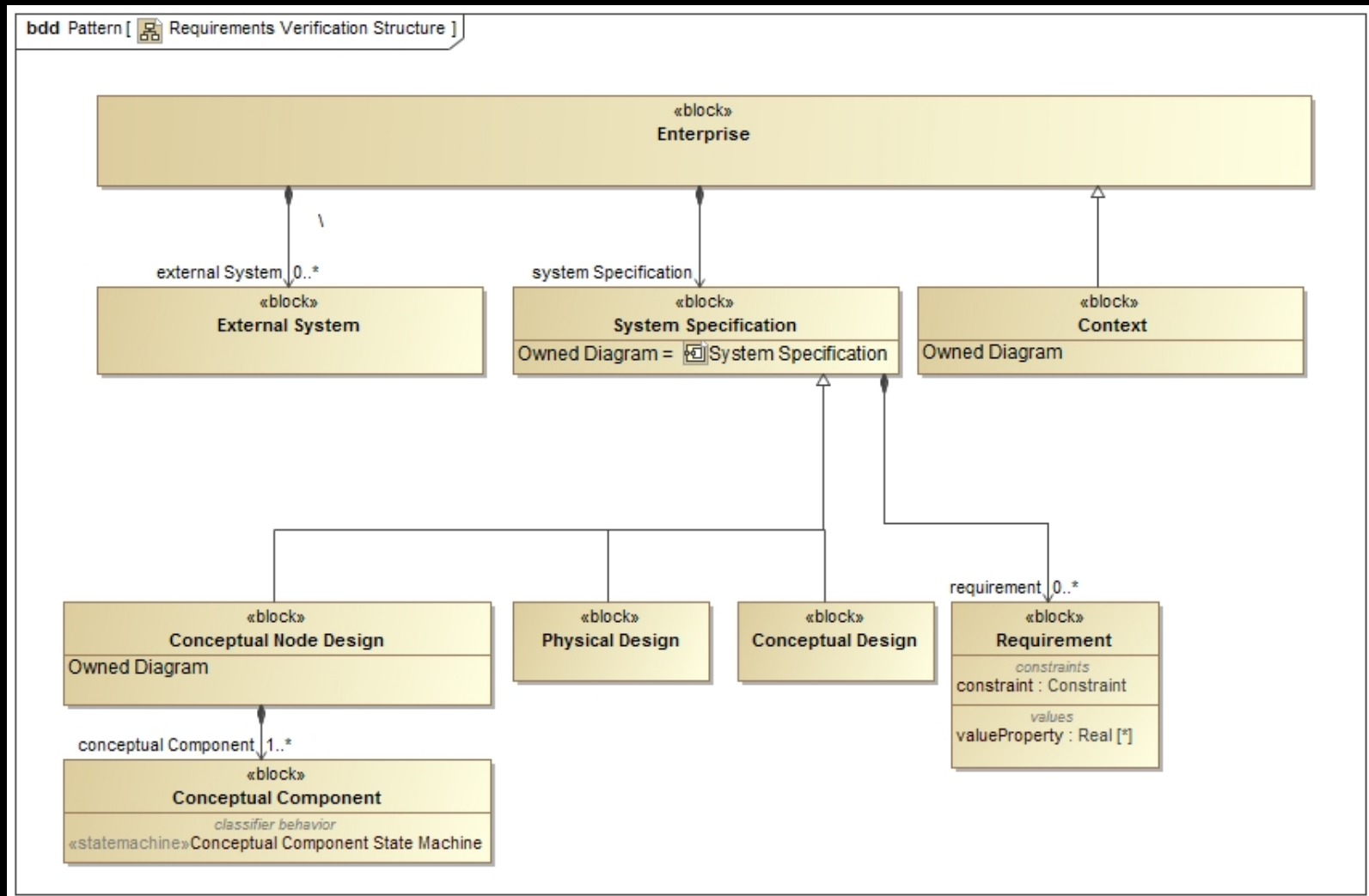
Run Analyses

- Run a configured analysis with a simulation engine on the initial conditions to get the final conditions
- Produce the analyses declaratively, repeatably (in any system), without a single line of project-specific code -> reducing time and resources
- Produce the following views on final conditions
 - **Table** showing final analysis values (e.g. peak power) and the constraint's pass/fail status for each scenario
 - **Timelines**: state changes for components over time
 - **Value profiles**: total rolled up values over time

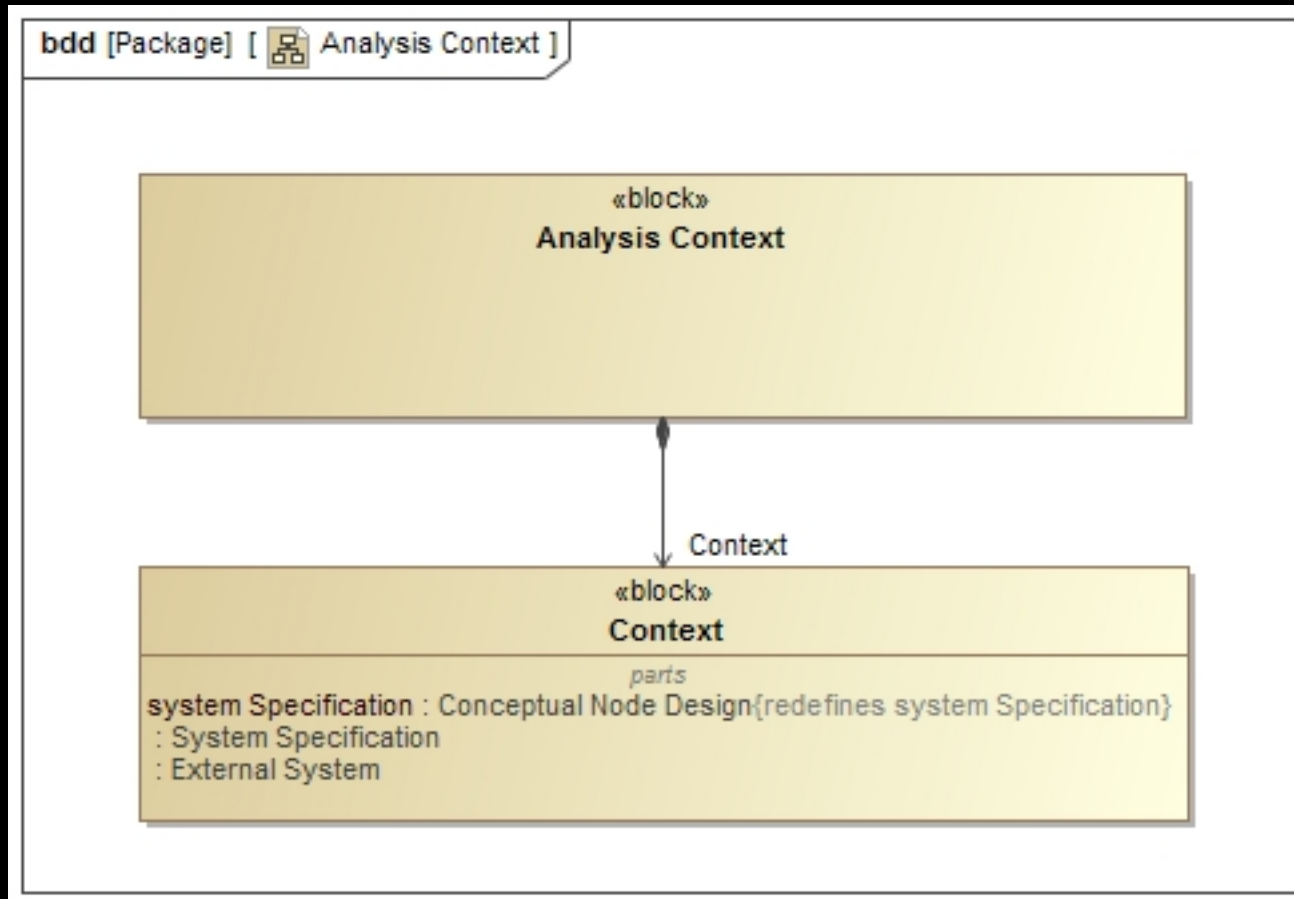


#	Name	Classifier	T Final : Real	Ph
1	calibrations Duration S	Calibrations Duration S		
2	calibrations Duration S	APS Conceptual		
3	calibrations Duration S	Procedure Executive an	8466.0	11

System Context

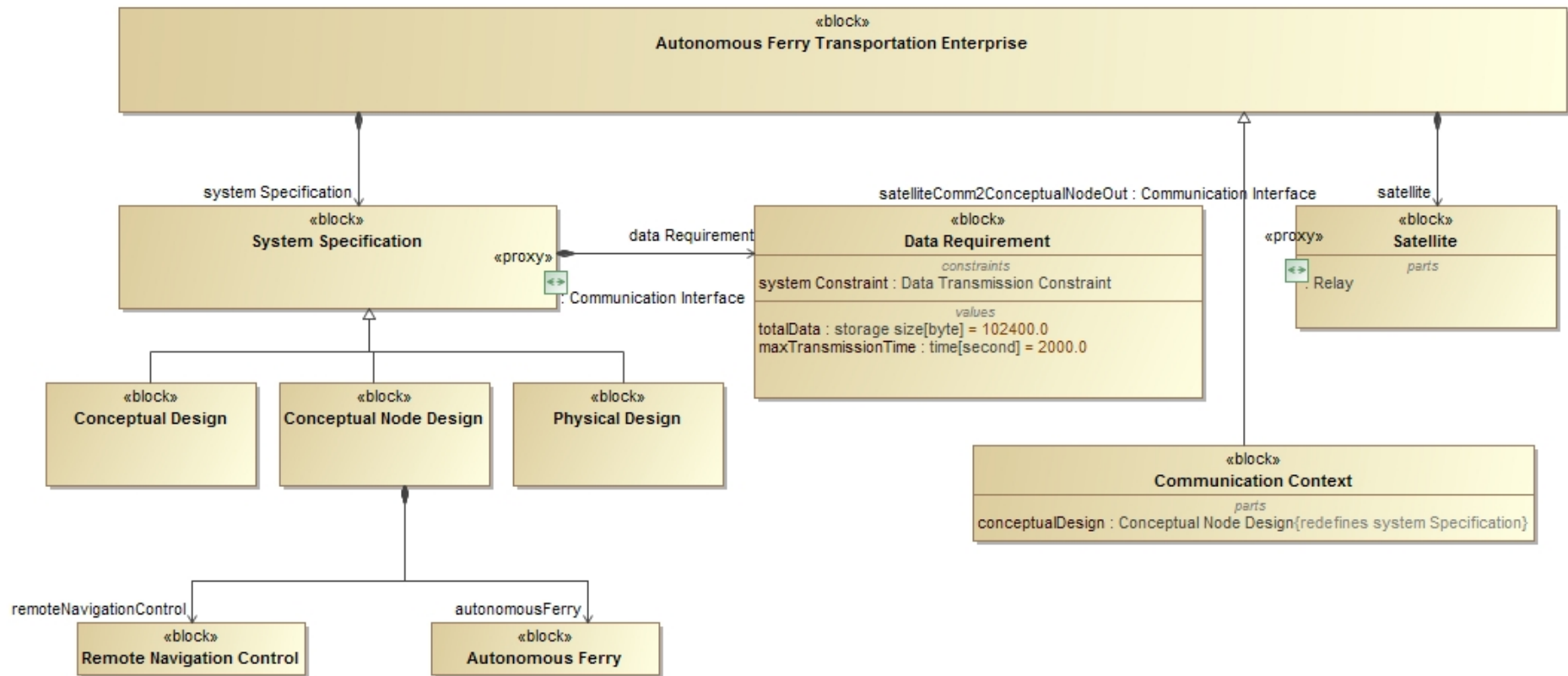


Analysis Context

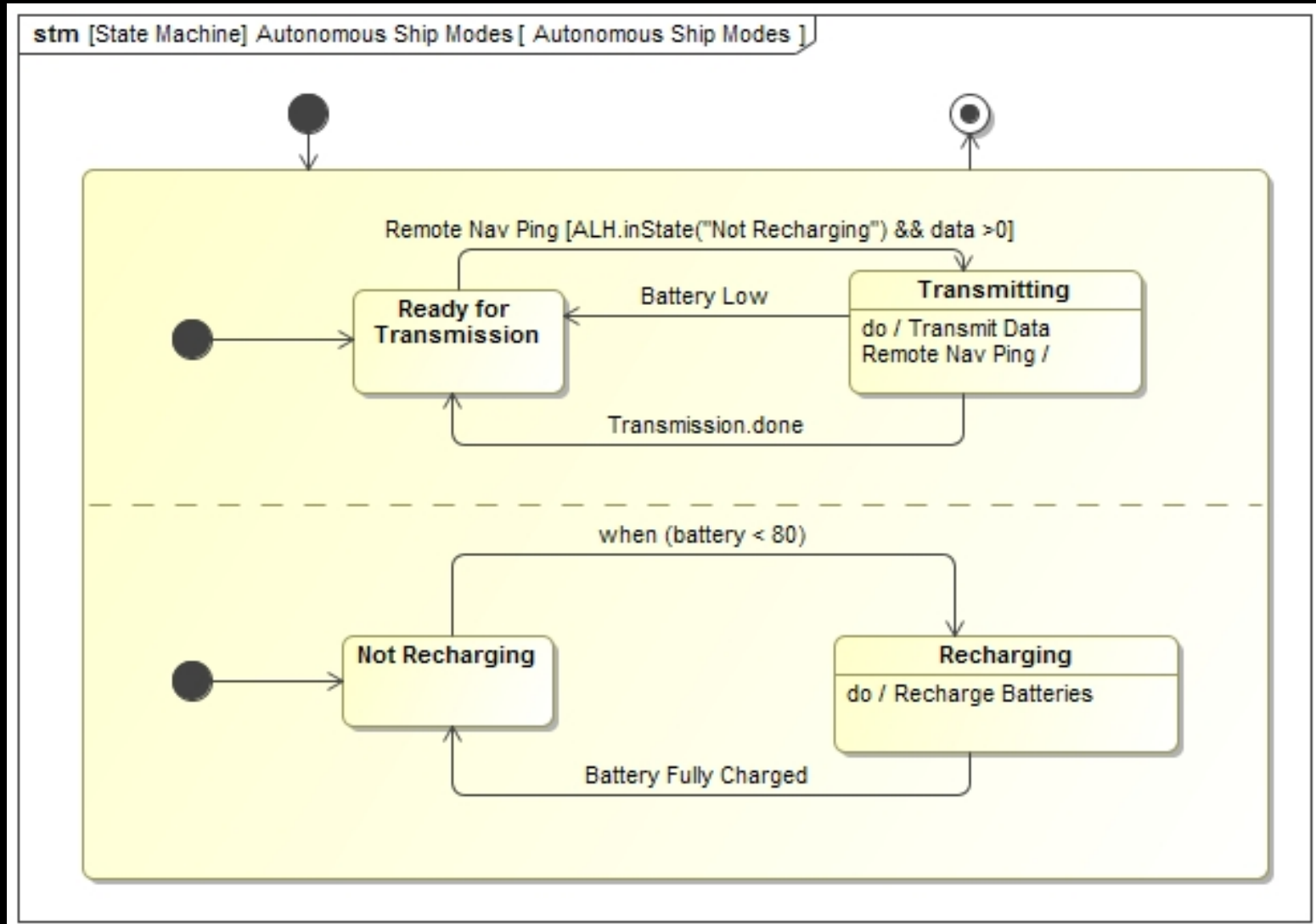


Context Educational Example

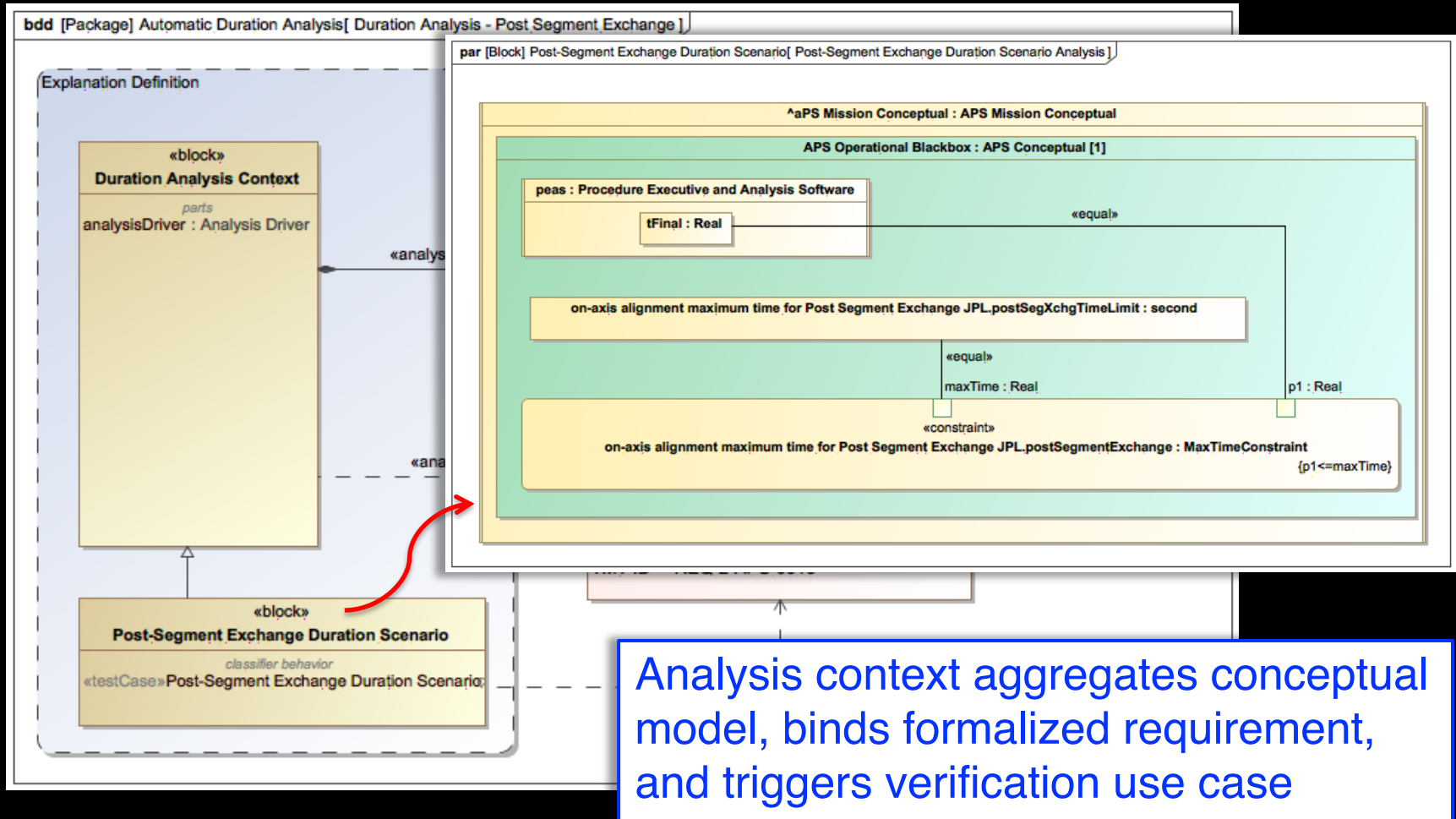
bdd [Package] Structure [ Structural Decomposition]



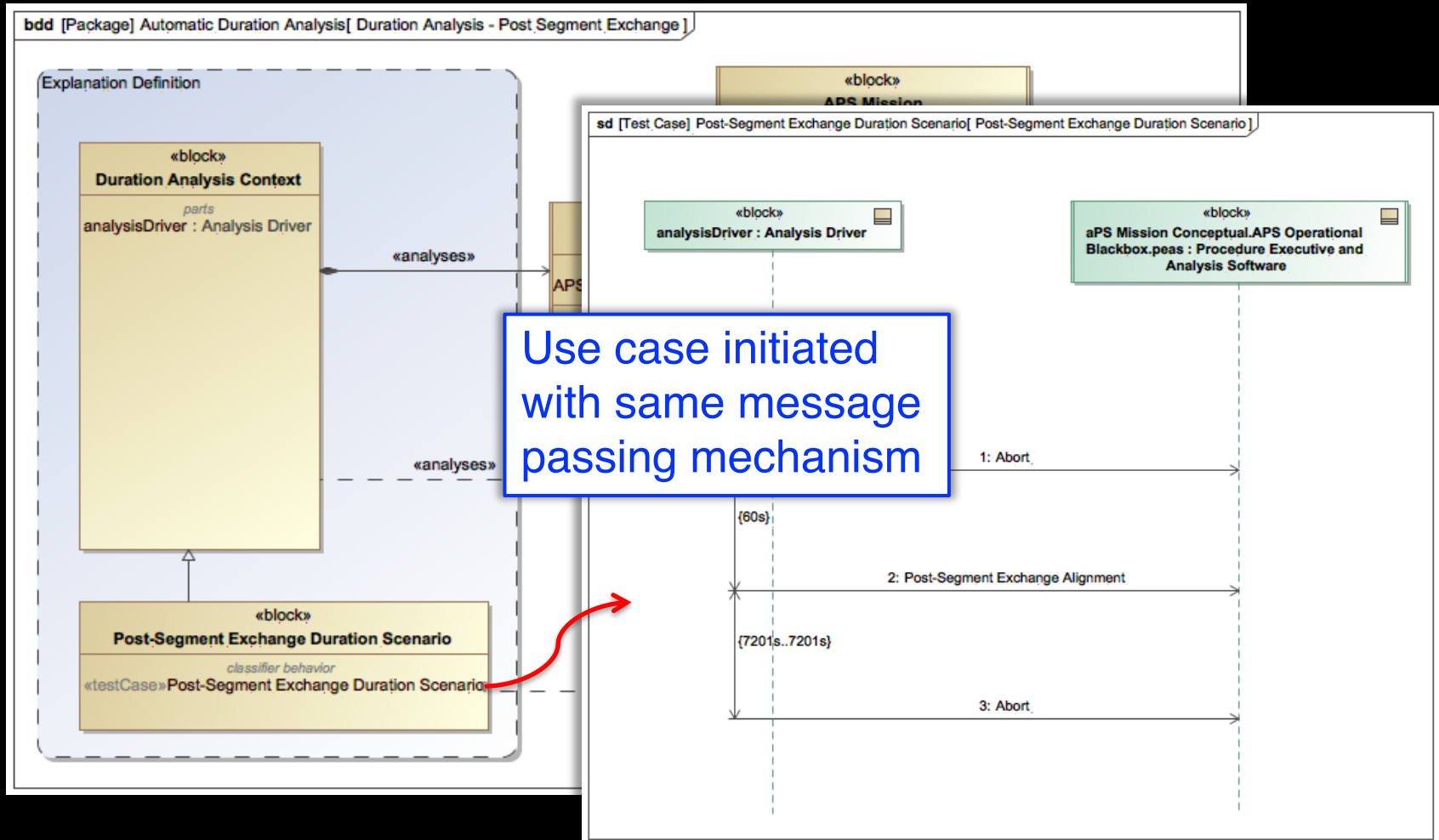
Behavior Ship



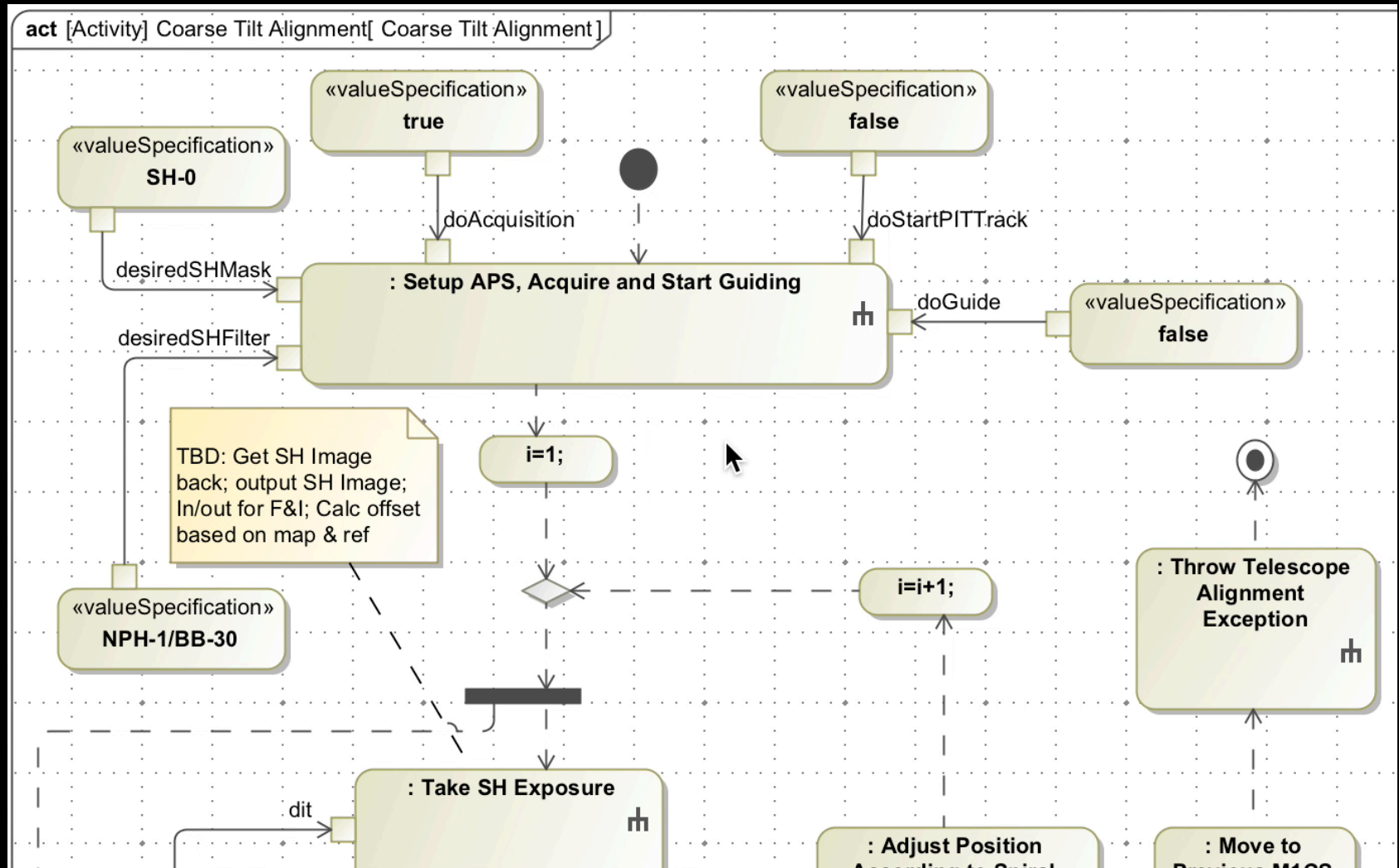
Verifying Timing Requirements by Simulation



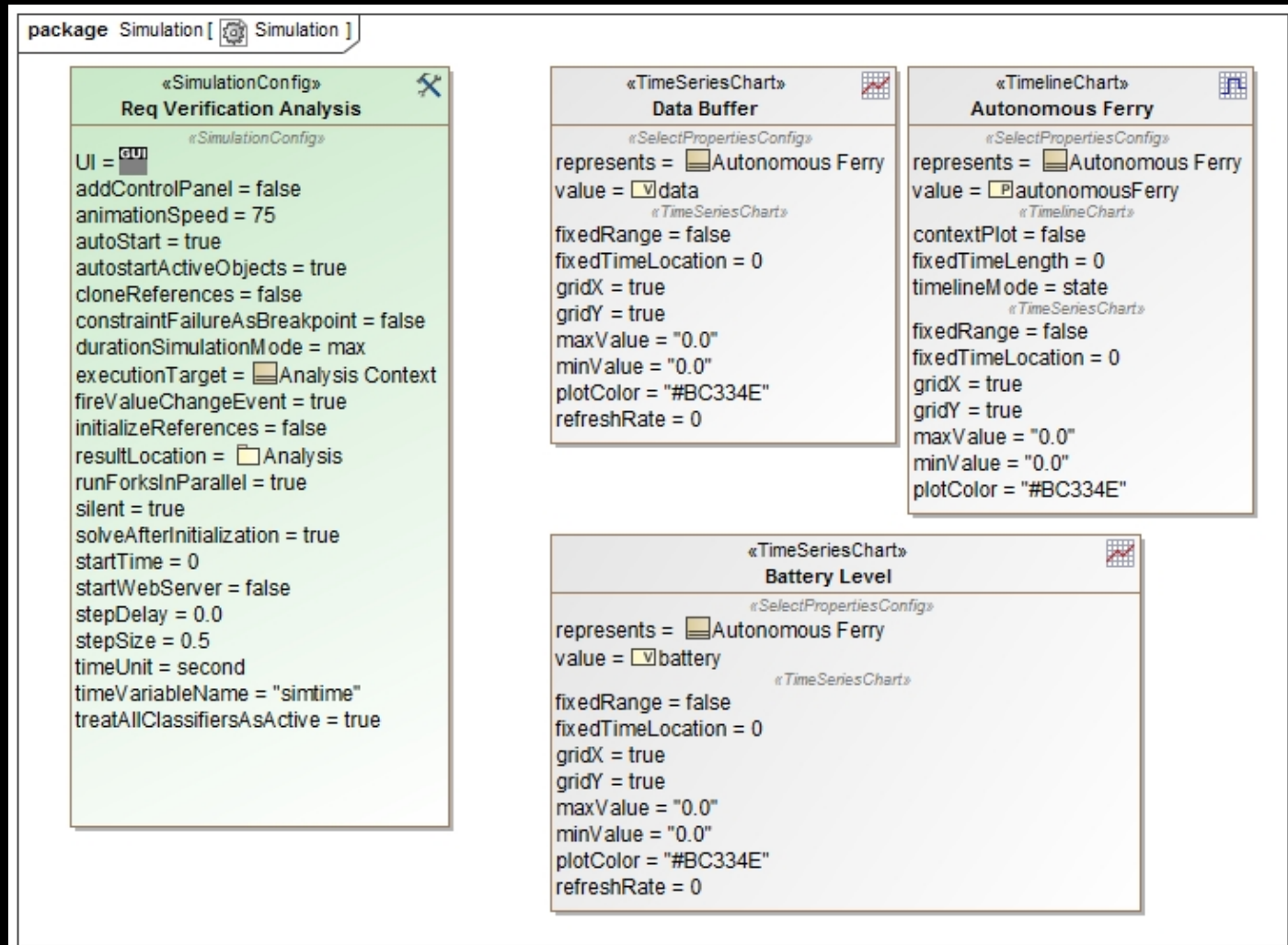
Verifying Timing Requirements by Simulation



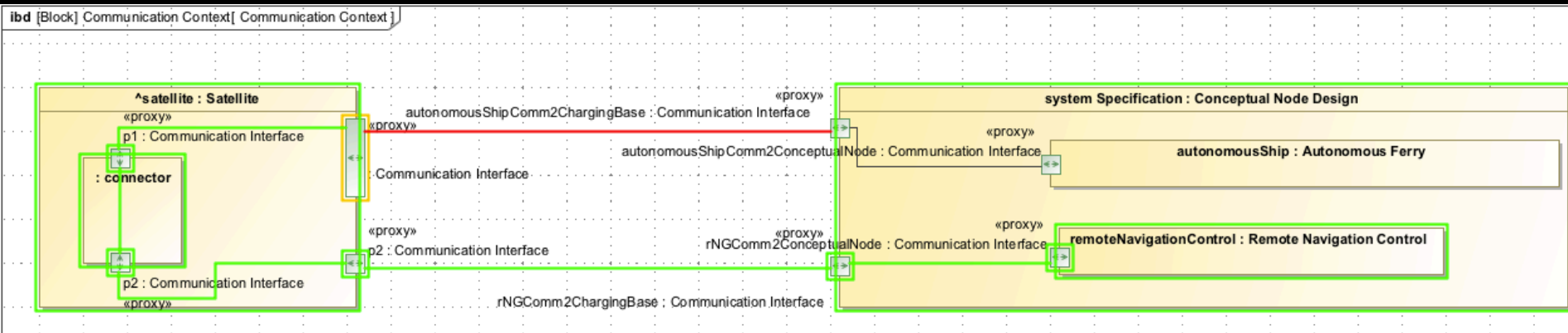
Verifying Timing Requirements by Simulation



Simulation Configuration with Cameo



Executing a scenario



Simulation Run

Simulation interface showing the current state of the simulation.

Trigger: [Dropdown menu] **Animation speed:** [Slider]

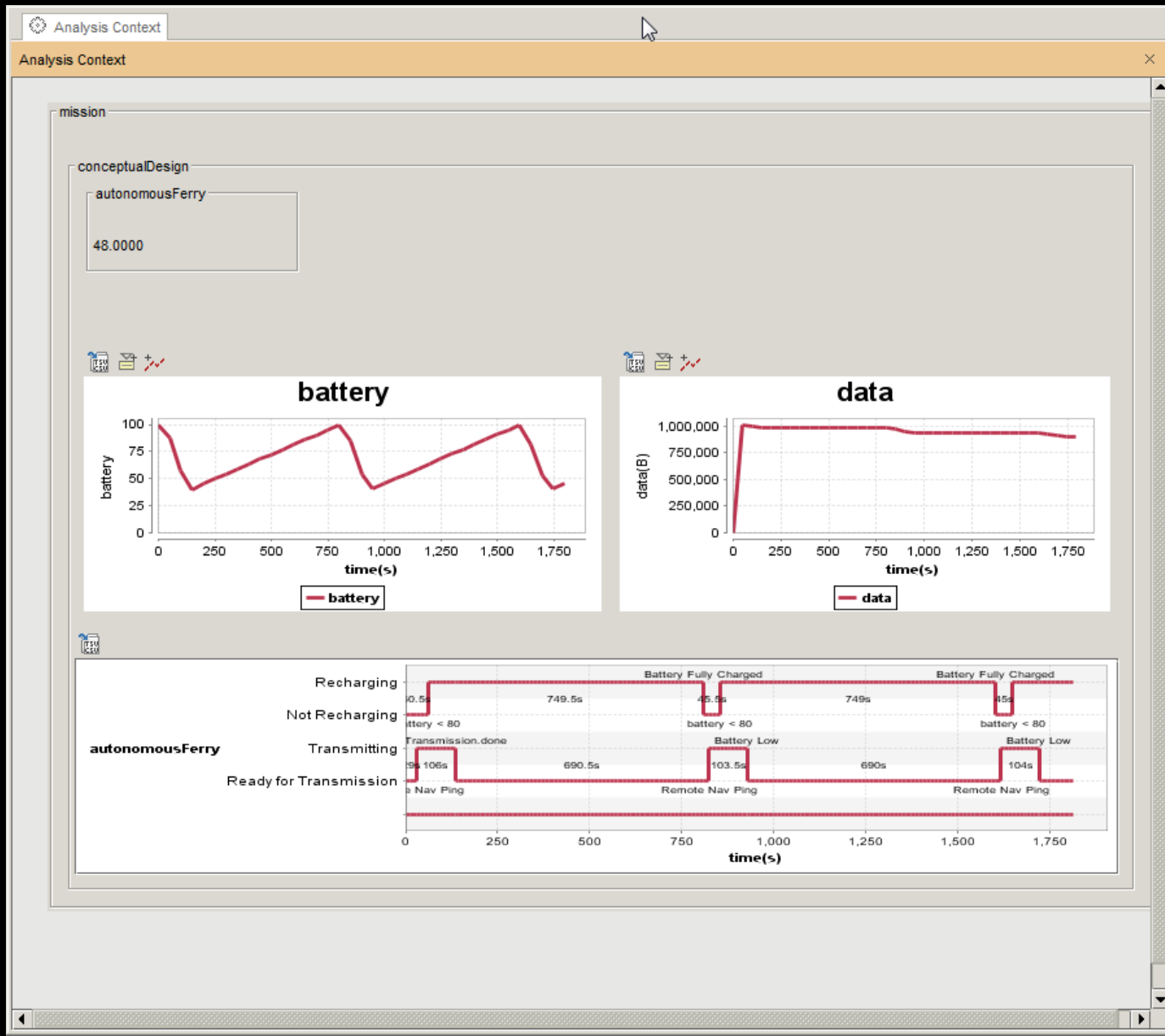
Sessions:

- Analysis Context [Analysis Context@3e30001d] (Paused)
- Operational Scenario [Analysis Context@3e30001d] (Paused)
- Autonomous Ship Modes(classifier behavior) [Autonomous Ferry@15f813a8] (Paused)
- Remote Navigation Control(classifier behavior) [Remote Navigation Control@1b98291b] (Started)
- Transmit Data [Autonomous Ferry@15f813a8] (Paused)
- Transmit Data [Autonomous Ferry@15f813a8] (Paused)
- Receive Data [Remote Navigation Control@1b98291b] (Paused)
- Receive Data [Remote Navigation Control@1b98291b] (Paused)


Variables:

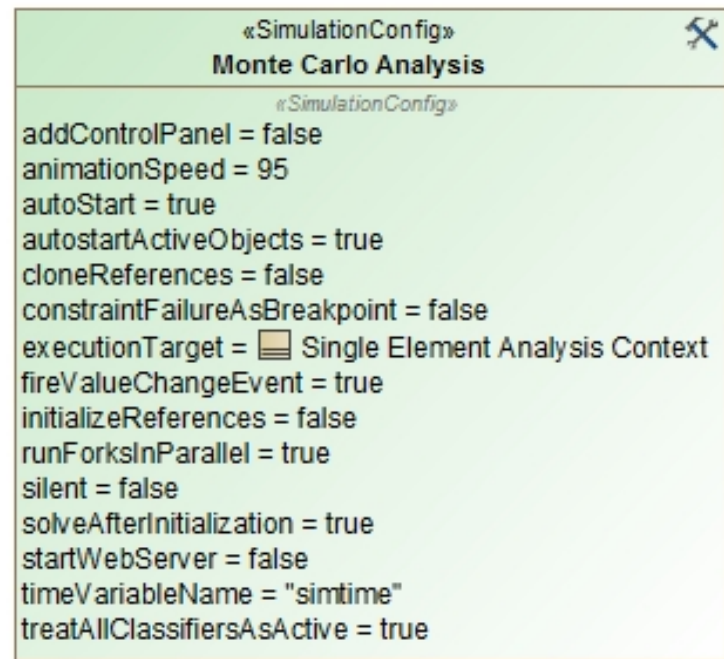
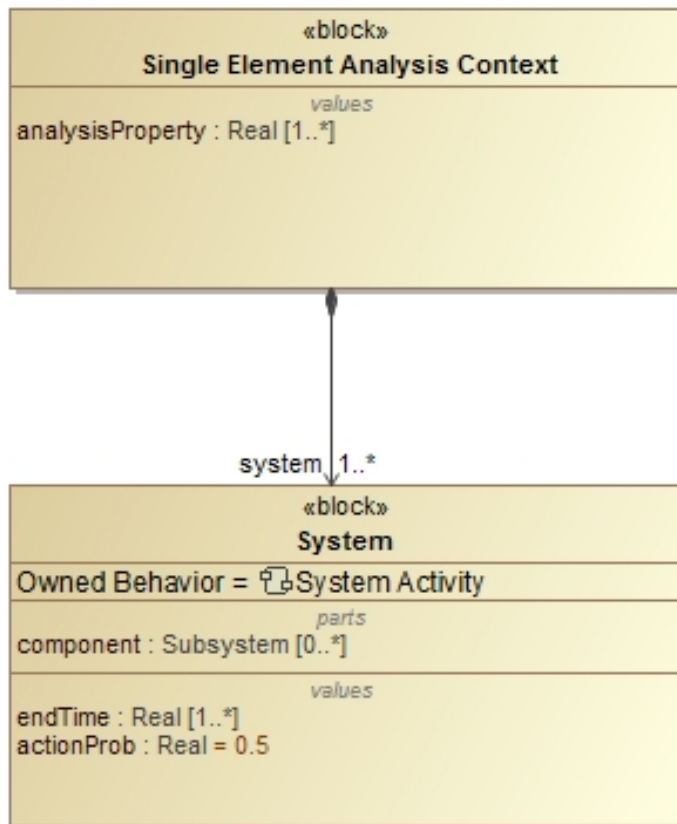
Name	Value
Analysis Context	Analysis Context@3e30001d
mission : Communication Context	Communication Context@7f94c337
satellite : Satellite	Satellite@5deb685b
connector	connector@5710aad8
system Specification : Conceptual Node Design	Conceptual Node Design@70c22cdc
autonomousFerry : Autonomous Ferry [, Not Recharging, Transmitting]	Autonomous Ferry@15f813a8
battery : Real	100.0000
data : storage size[byte]	1.0240E5
t0 : time[second]	23.7920
tfinal : Real	0.0000
transmissionInProgress : Boolean	<input checked="" type="checkbox"/> true
data Requirement : Data Requirement	Data Requirement@56fe571e
maxTransmissionTime : time[second]	300.0000
totalData : storage size[byte]	1.0240E5
system Constraint : Data Transmission Constraint (maxTransmissionTime...)	Data Transmission Constraint@375b3c11
designTime : time[second]	0.0000
maxTime : time[second]	300.0000
remoteNavigationControl : Remote Navigation Control [Operation]	Remote Navigation Control@1b98291b

Analysis by Simulation

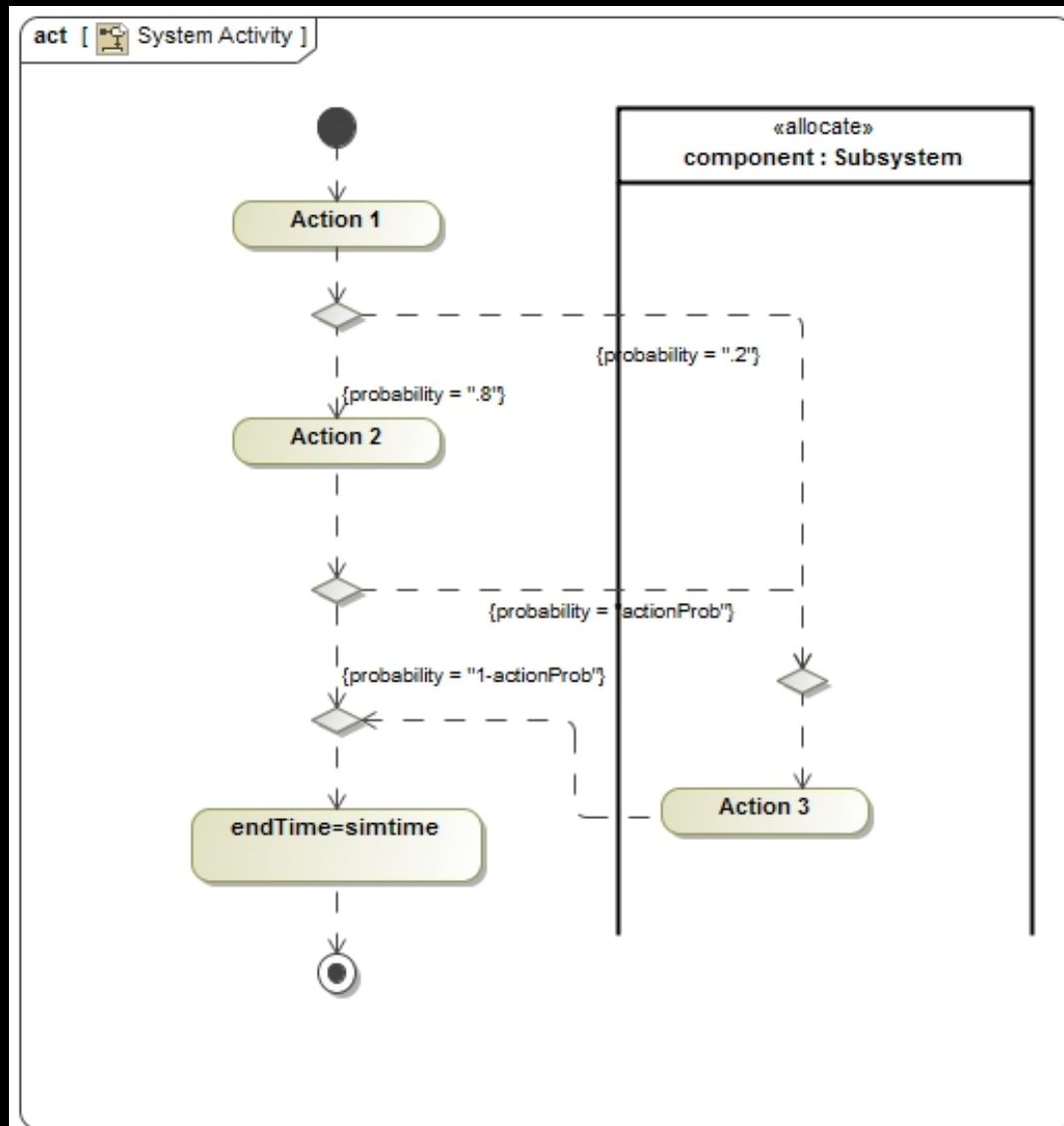


Single Element Analysis Context

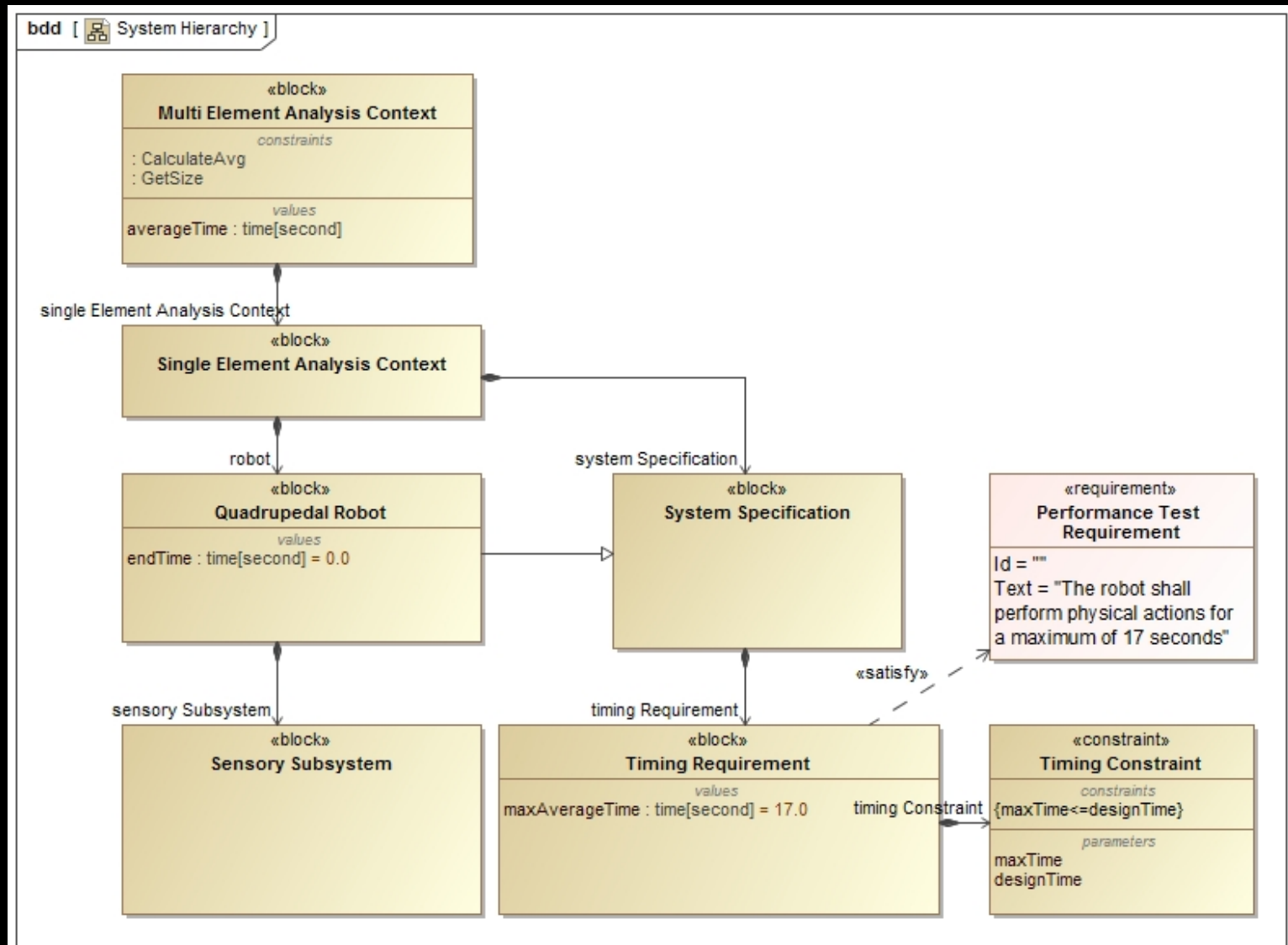
bdd [ Monte Carlo Simulation Components]



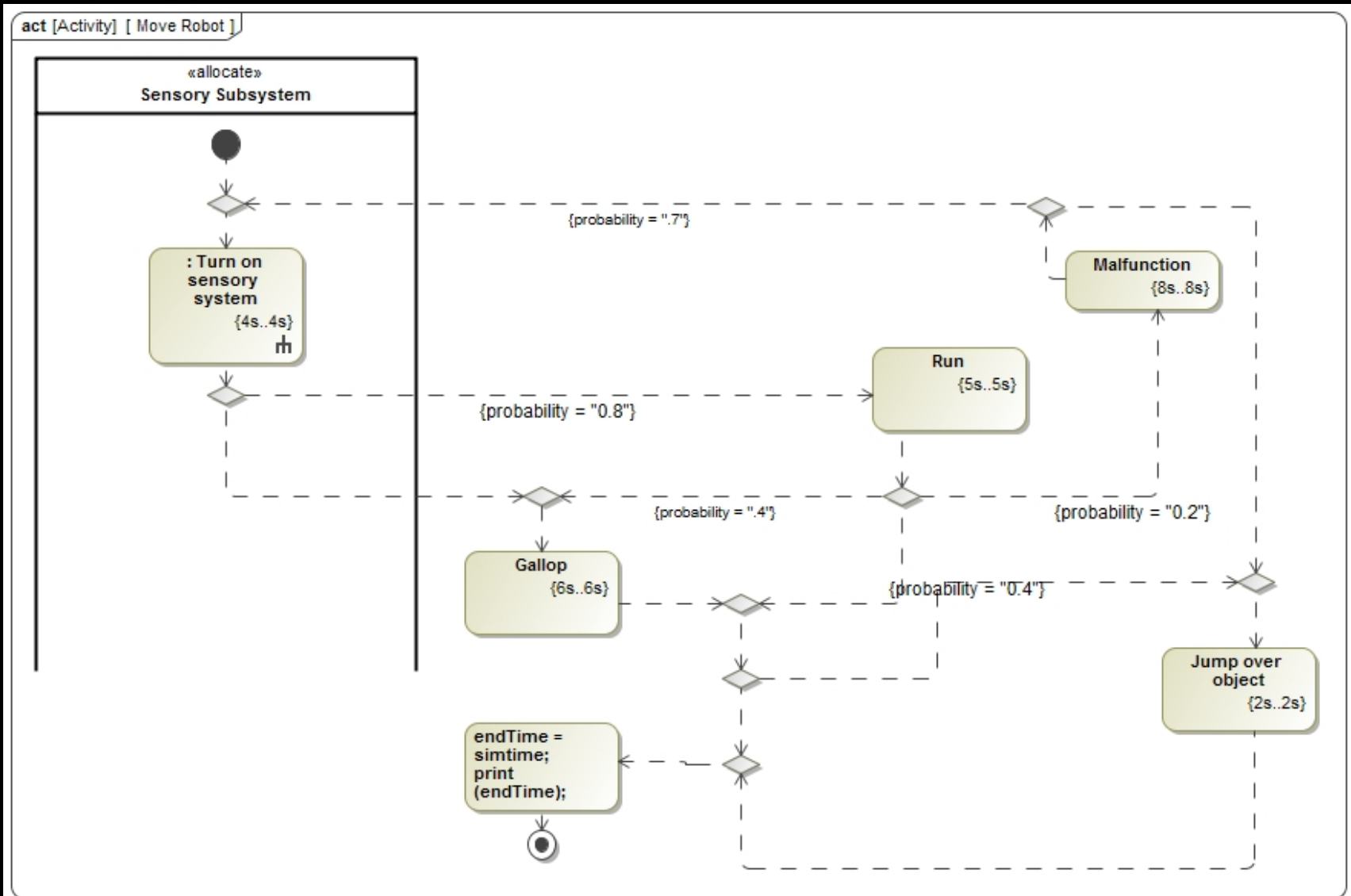
Behavior with Probability



Example Quadrapedal Robot



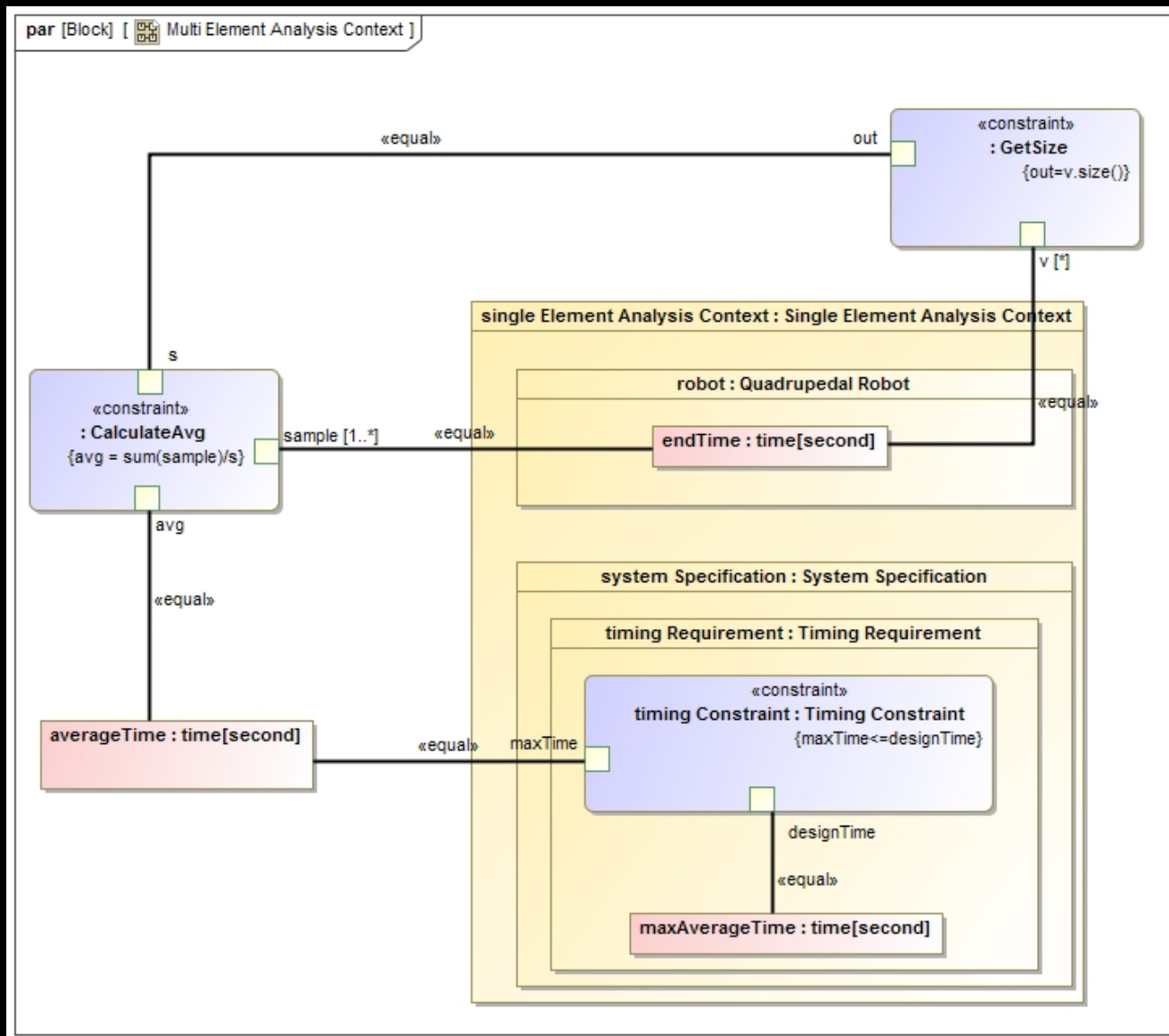
Behavior with probability







Individual Results

#	▽ Name	▼ endTime : time[second]
1	robot at 2017.07.20 17.38	10.0
2	robot at 2017.07.20 17.38	12.0
3	robot at 2017.07.20 17.38	15.0
4	robot at 2017.07.20 17.38	12.0
5	robot at 2017.07.20 17.38	17.0

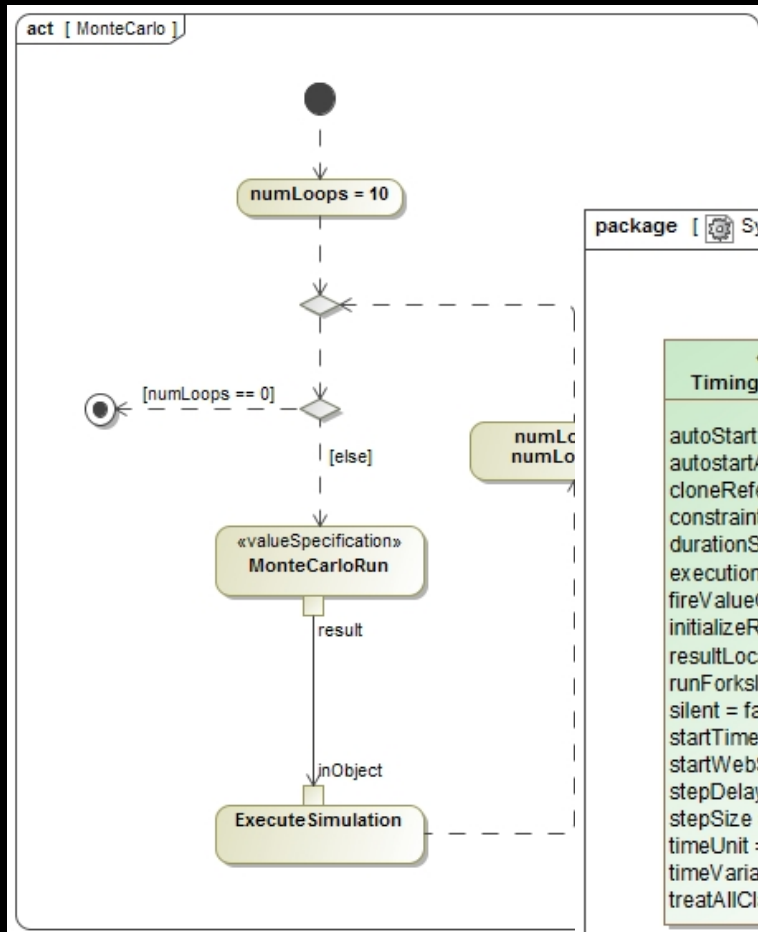
Analysis Context



Analysis Result

#	△ Name	 system Specification.timing Requirement.timing Constraint : Timing Constraint	 robot.endTime : time[second]
1	 single Element Analysis Context at 2017.07.28 11.32	 pass	12.0

Cameo Simulation Toolkit



package [System Timing Configuration]

«SimulationConfig»
Timing Analysis Model Based

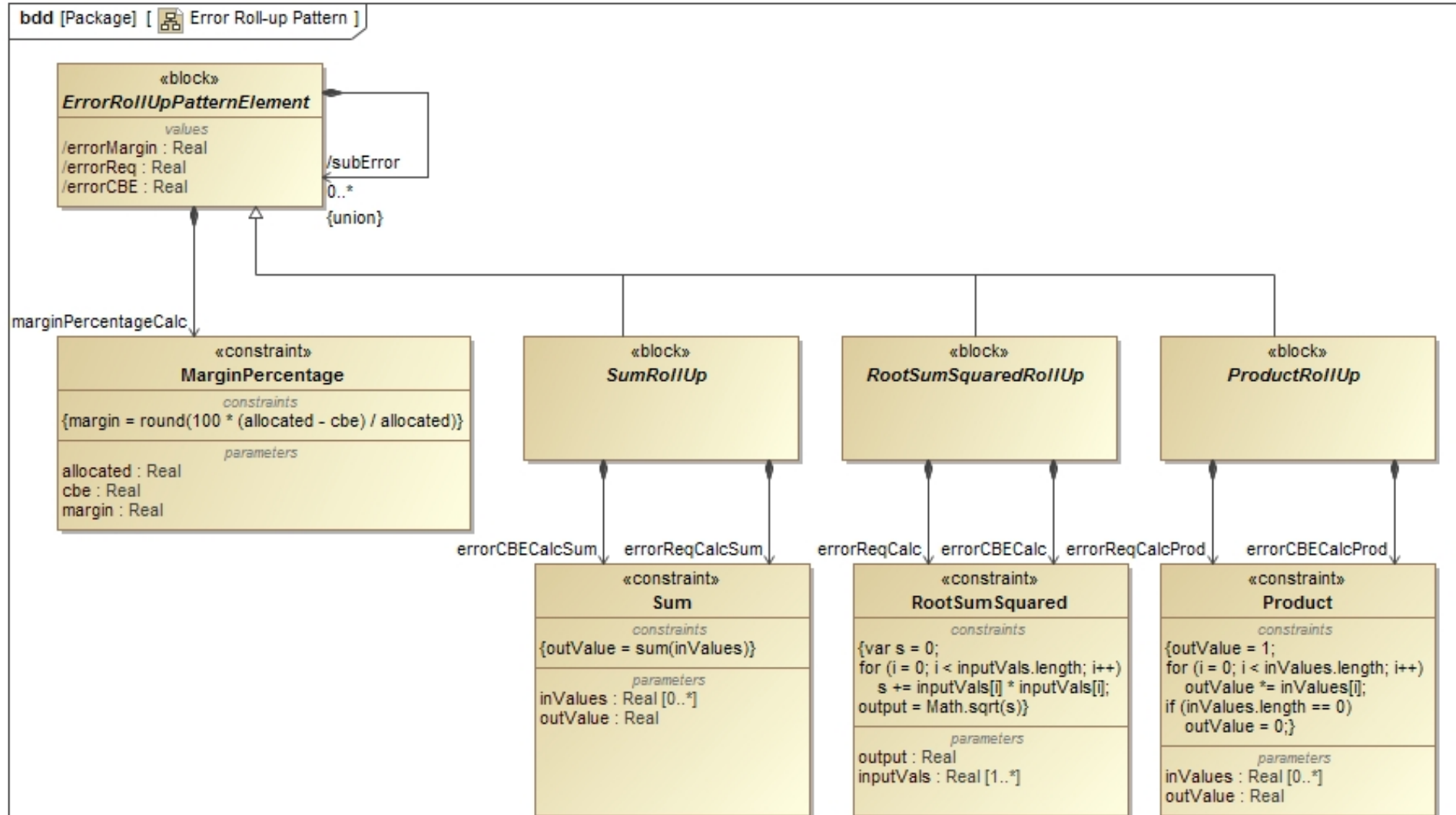
«SimulationConfig»
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = max
executionTarget = System
fireValueChangeEvent = true
initializeReferences = false
resultLocation = Results
runForksInParallel = true
silent = false
startTime = 0
startWebService = false
stepDelay = 0
stepSize = 1
timeUnit = second
timeVariable = time
treatAllClassesAsAtomic = false

«SimulationConfig»
Timing Analysis PC

«SimulationConfig»
autoStart = true
autostartActiveObjects = true
constraintFailureAsBreakpoint = false
executionTarget = System
fireValueChangeEvent = true
resultLocation = Results
silent = true
timeUnit = second

#	△ Name	endTime : Real
1	system at 2017.07.18 18.19	3.0
2	system at 2017.07.18 18.19	7.0
3	system at 2017.07.18 18.20	7.0
4	system at 2017.07.18 18.20	15.0
5	system at 2017.07.18 18.21	15.0
6	system at 2017.07.20 14.18	0.127
7	system at 2017.07.20 14.18	0.124
8	system at 2017.07.20 14.18	0.046

Error Roll-up Pattern



RSS Parametric Model

par [Block] RootSumSquaredRollUp [ErrorCBECalc]

^/errorCBE : Real

«equal»

output

^/subError : ErrorRollUpPatternElement [0..*]

/errorCBE : Real

«equal»

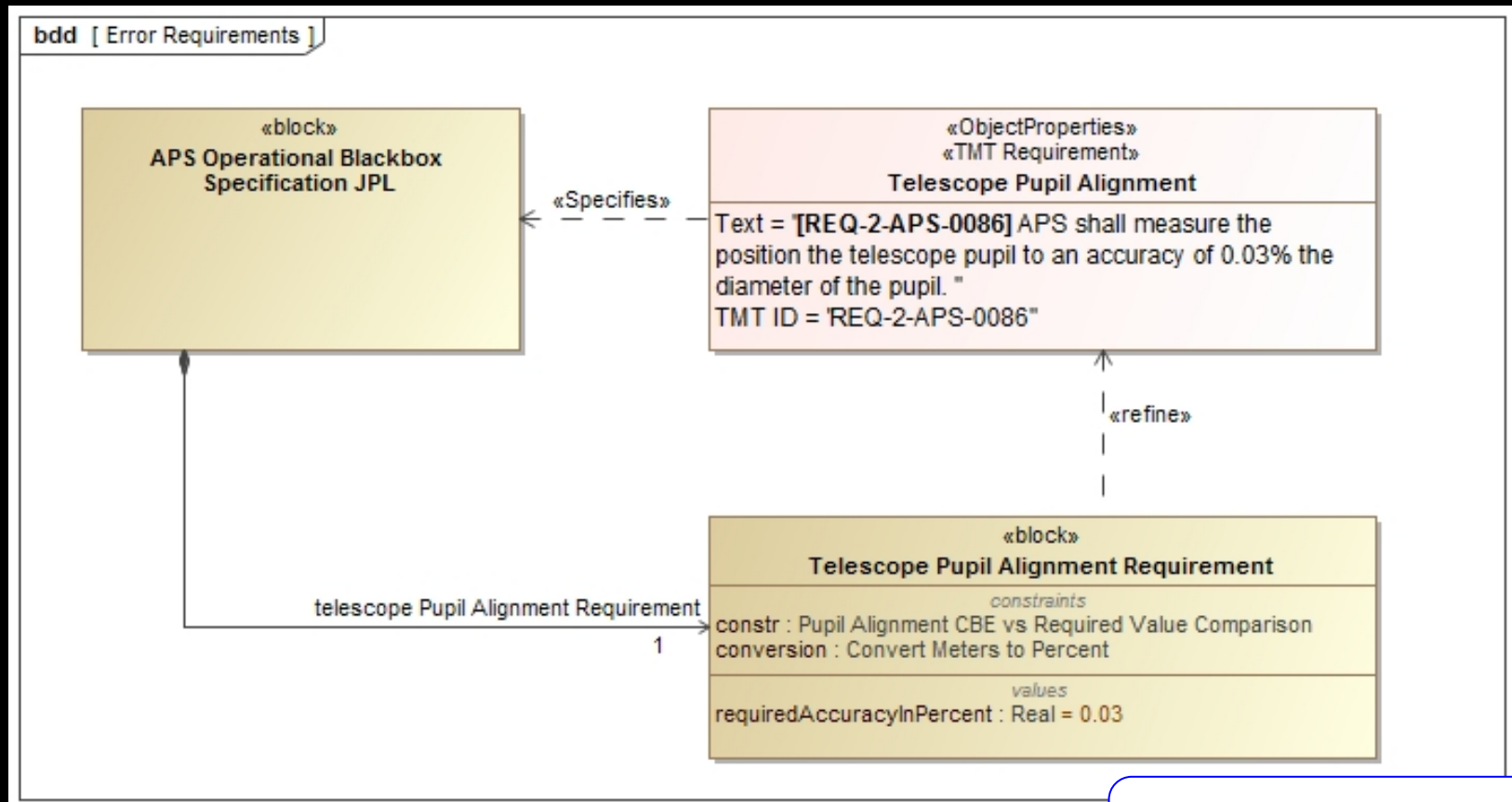
inputVals [1..*]

«constraint»

errorCBECalc : RootSumSquared

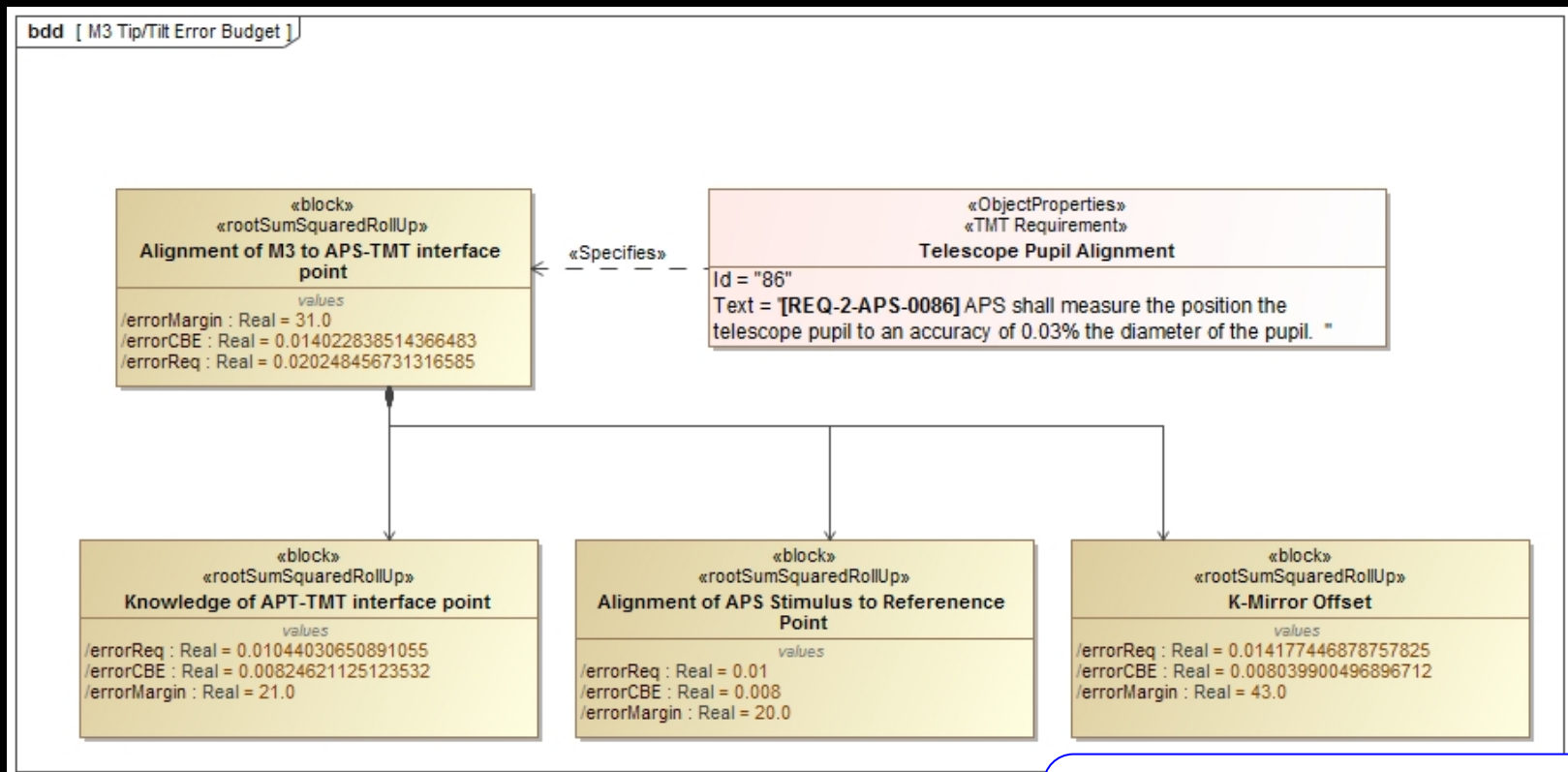
```
{var s = 0;  
for (i = 0; i < inputVals.length; i++)  
  s += inputVals[i] * inputVals[i];  
output = Math.sqrt(s)}
```

APS - Alignment error of the M3 to APS interface



Context

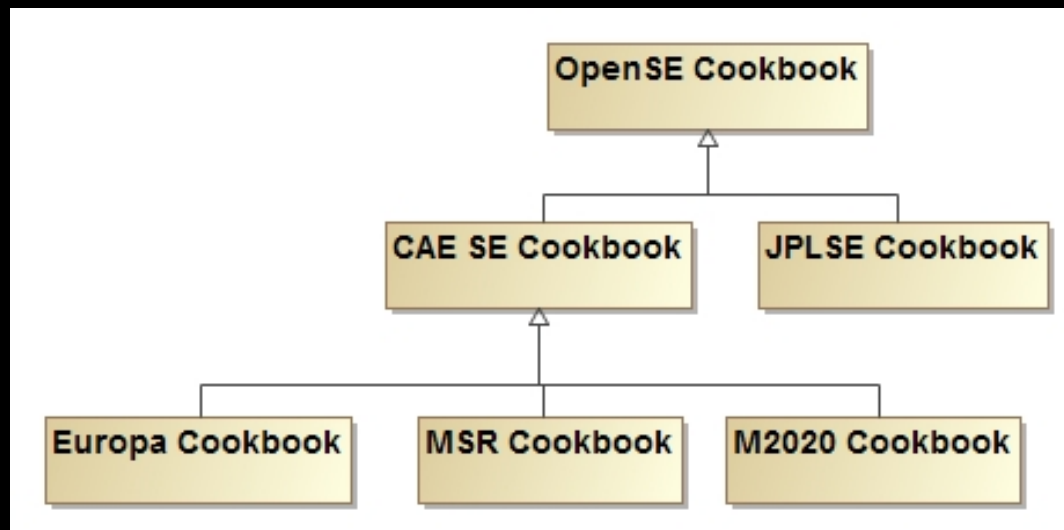
Specify RSS Tree



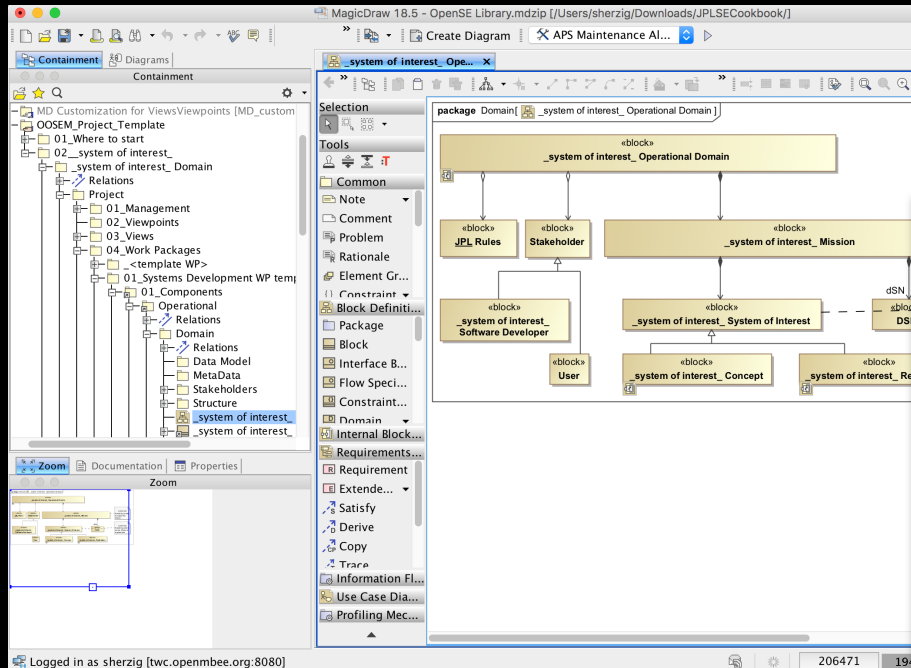
Application of pattern

OpenSE Cookbook promotes re-use

- OpenSE Cookbook contributes to JPL institutional and project specific Cookbooks
- Project-independent modeling patterns as guidelines
- Project-specific modeling patterns for common modeling tasks



OpenSE Cookbook and Template Model



“Cookbook” for modeling methodology & patterns

MBSE Initiative – SE2 Challenge

COOKBOOK FOR MBSE WITH SYSML

Issue 1
19/01/2011

SE2 Cookbook for MBSE with SysML

comprehensive product tree may in theory be satisfied by automatically merging all existing product tree diagrams into a big one (remember, each sub-system contains recursively its product tree).

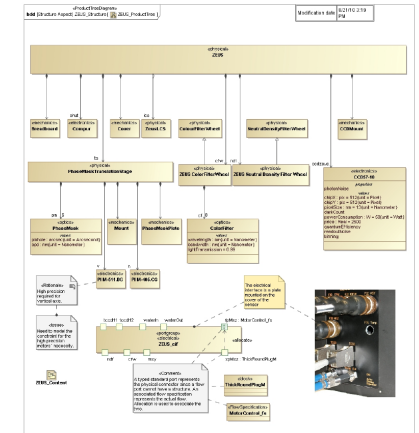


Figure 5 Product Tree of the ZEUS subsystem

ZEUS is one of the evaluated phasing sensors (Figure 5) and is based on the modified Michelson interferometer phasing sensor. It is mounted on a breadboard and consists of a shutter, a cover, a color filter wheel, a neutral density filter wheel, and a translation stage which carries a phase mask. Different phase masks can be moved to the focal position by means of a translation stage, able to move in the X and Y directions.

The two filter wheels located after the phase mask translation stage:

- A neutral Density Filter wheel: a set of 8 different neutral density filters are available
- An optical filter wheel: a set of 8 different optical filters centered on different wavelengths and with different bandwidths are available

Template models to be used by projects as a starting point, with recommended organization, model libraries, etc.

OpenSE Cookbook is used as reference

- OpenSE cookbook and TMT model used as reference model for the OMG SysML 2 standard
 - Demonstrate how SysML 2 will improve, simplify, change model wrt SysML 1.x
- Training material and knowledge transfer
- Promote standards and conventions
- Used by vendors as reference to test and evolve products

Define APS Mission boundaries

TMT specification handed to JPL

«block»

APS Black Box Specification TMT

«block»
APS Operational Blackbox
Specification JPL

JPL realization of APS

Other TMT Subsystems

Operator

Modeled high-level
behavior of interfacing
components

APS Black Box

TCS

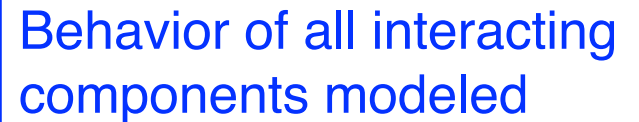
M1CS

CS

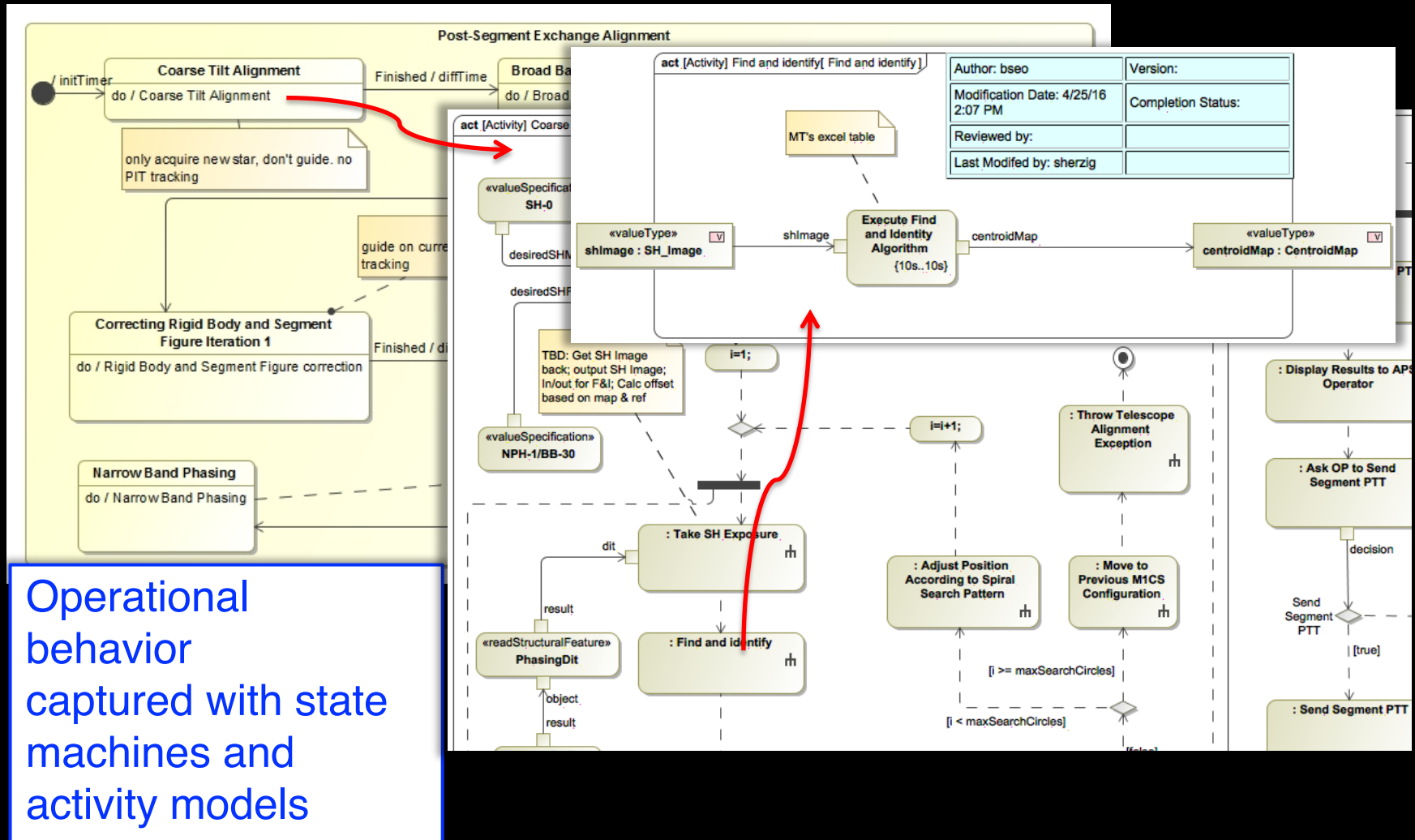
ESW

Interfaces between APS and other subsystems

APS conceptual is broken down into several components

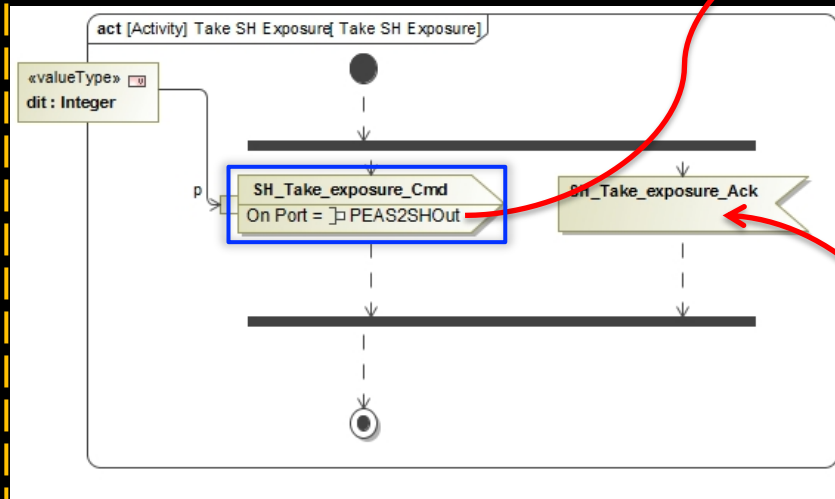


Capture Component Behavior and Characteristics



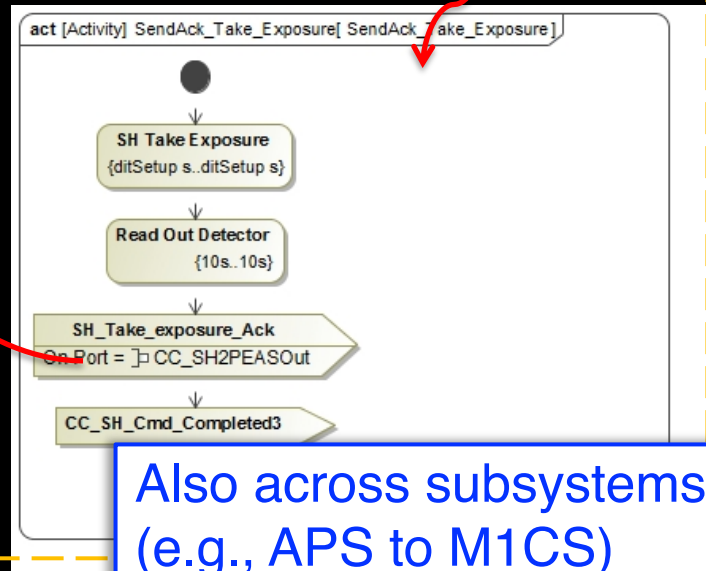
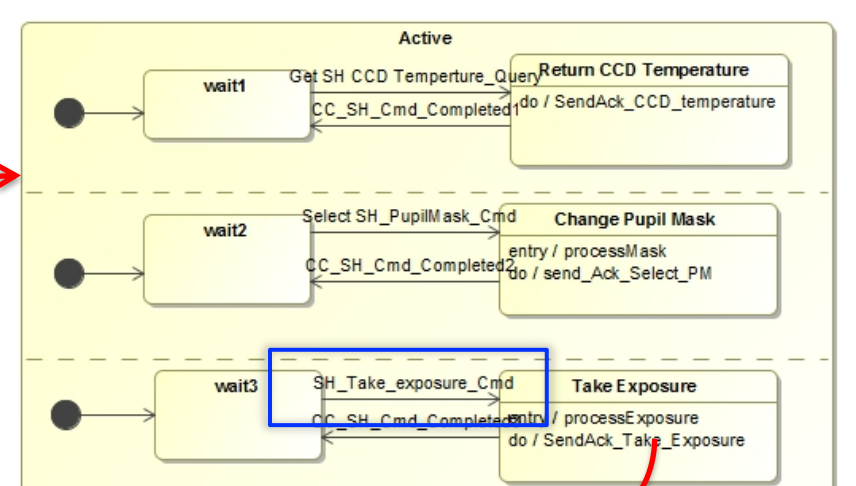
Specify Interactions Between Components

PEAS Context



Use of signals sent over ports to simulate a message passing mechanism between components

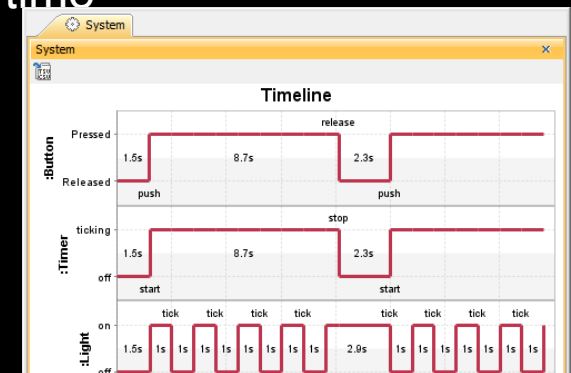
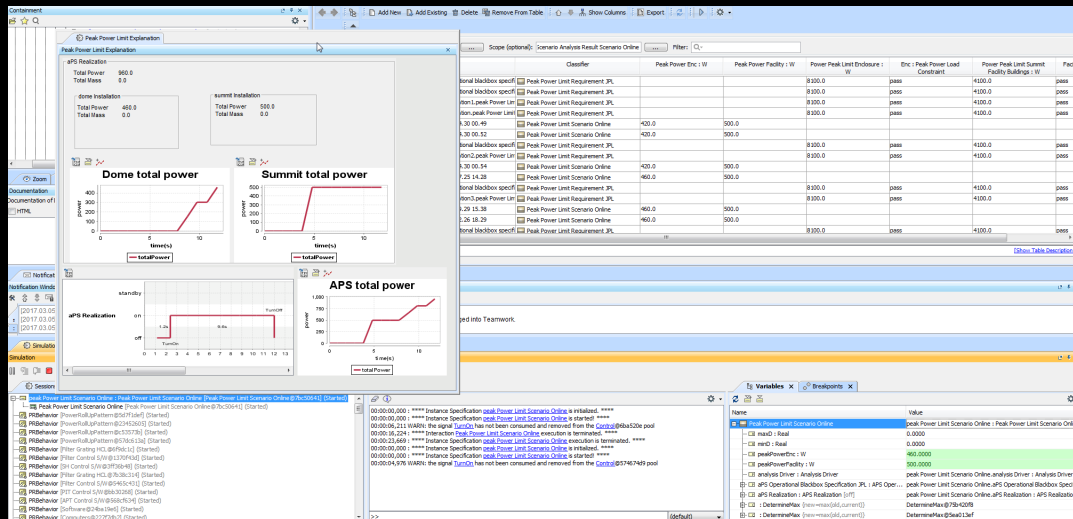
SH Camera Context



Also across subsystems!
(e.g., APS to M1CS)

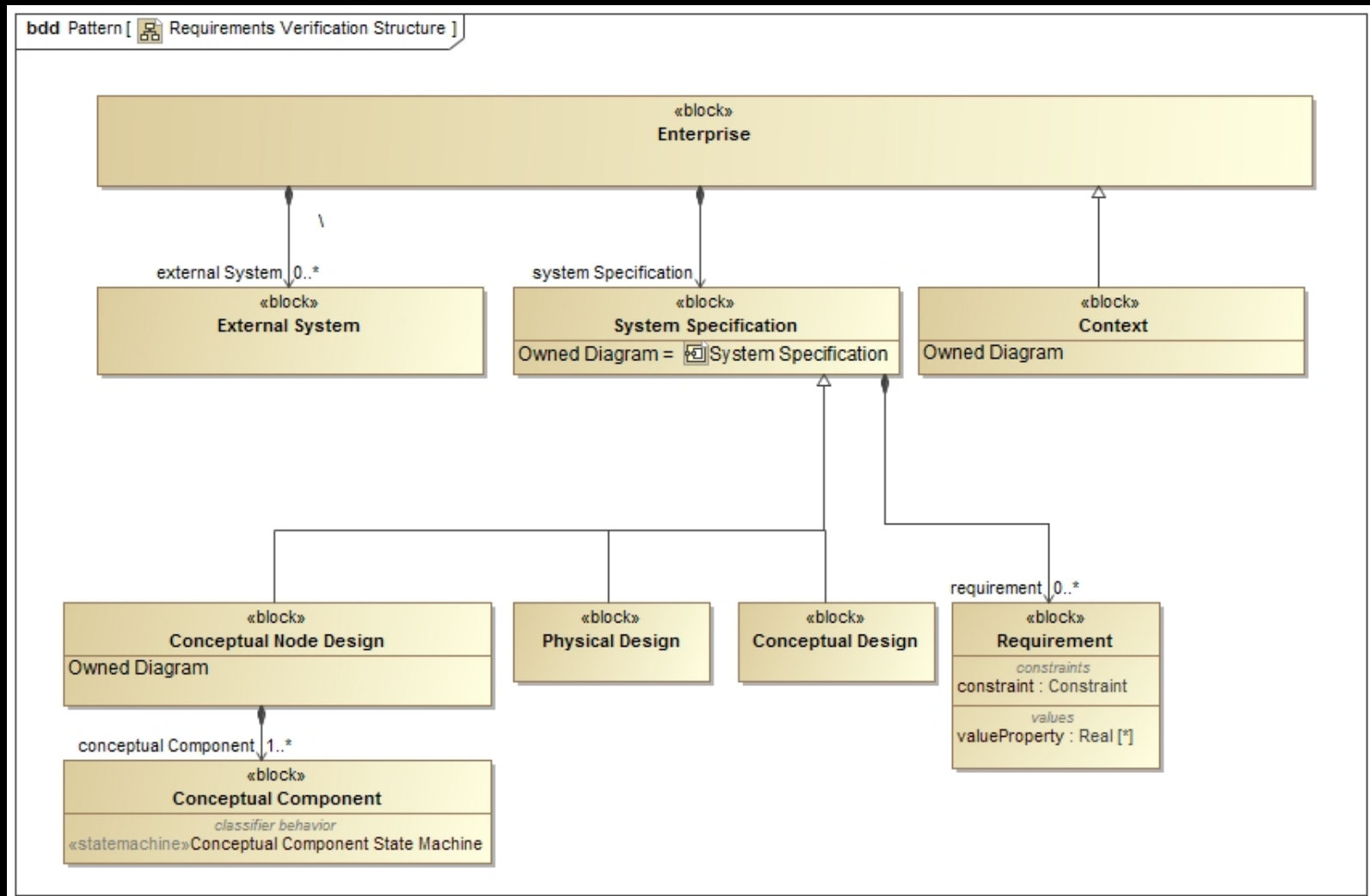
Run Analyses

- Run a configured analysis with a simulation engine on the initial conditions to get the final conditions
- Produce the analyses declaratively, repeatably (in any system), without a single line of project-specific code -> reducing time and resources
- Produce the following views on final conditions
 - **Table** showing final analysis values (e.g. peak power) and the constraint's pass/fail status for each scenario
 - **Timelines**: state changes for components over time
 - **Value profiles**: total rolled up values over time

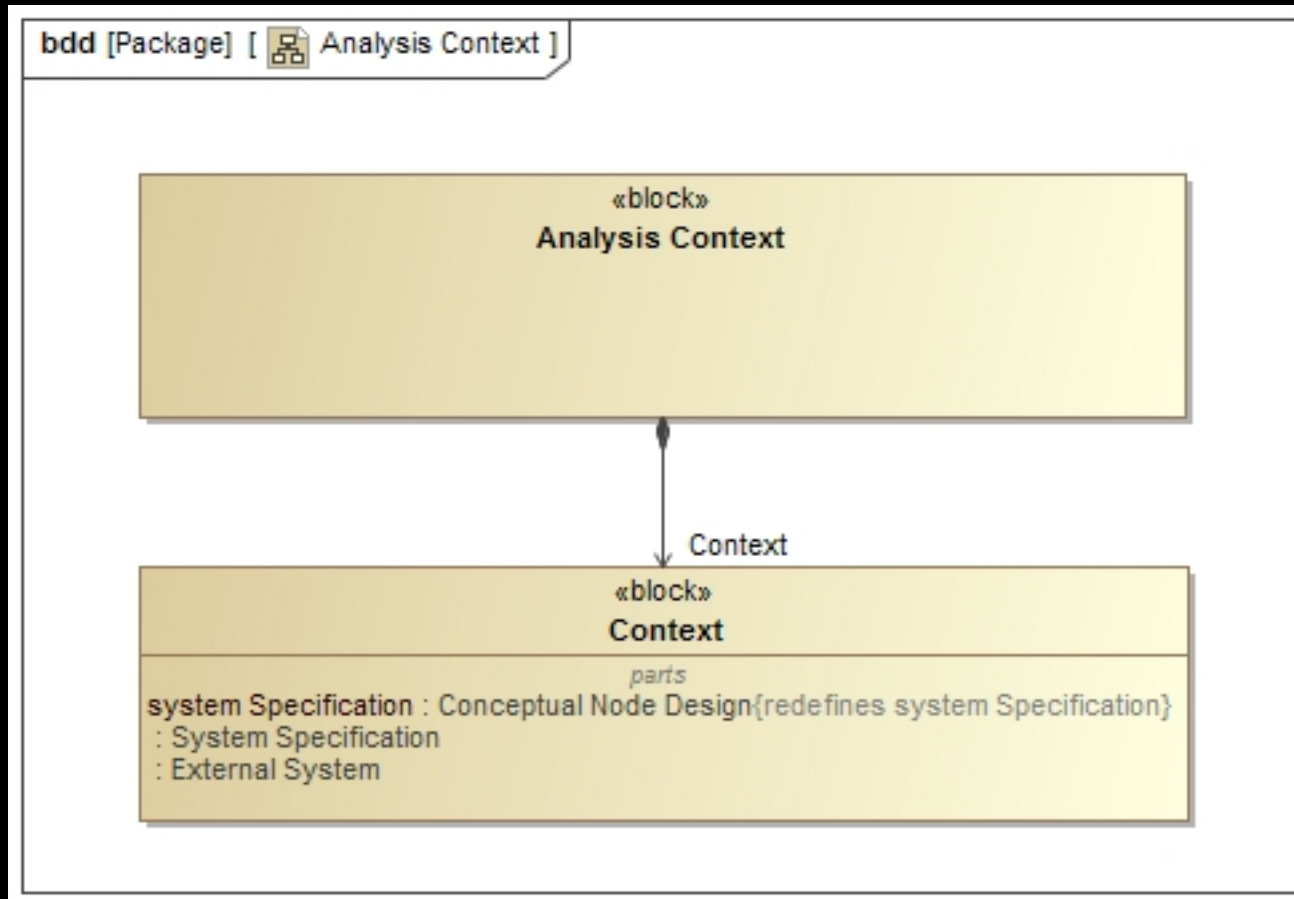


#	Name	Classifier	T Final : Real	Ph
1	calibrations Duration S	Calibrations Duration S		
2	calibrations Duration S	APS Conceptual		
3	calibrations Duration S	Procedure Executive an	8466.0	11

System Context

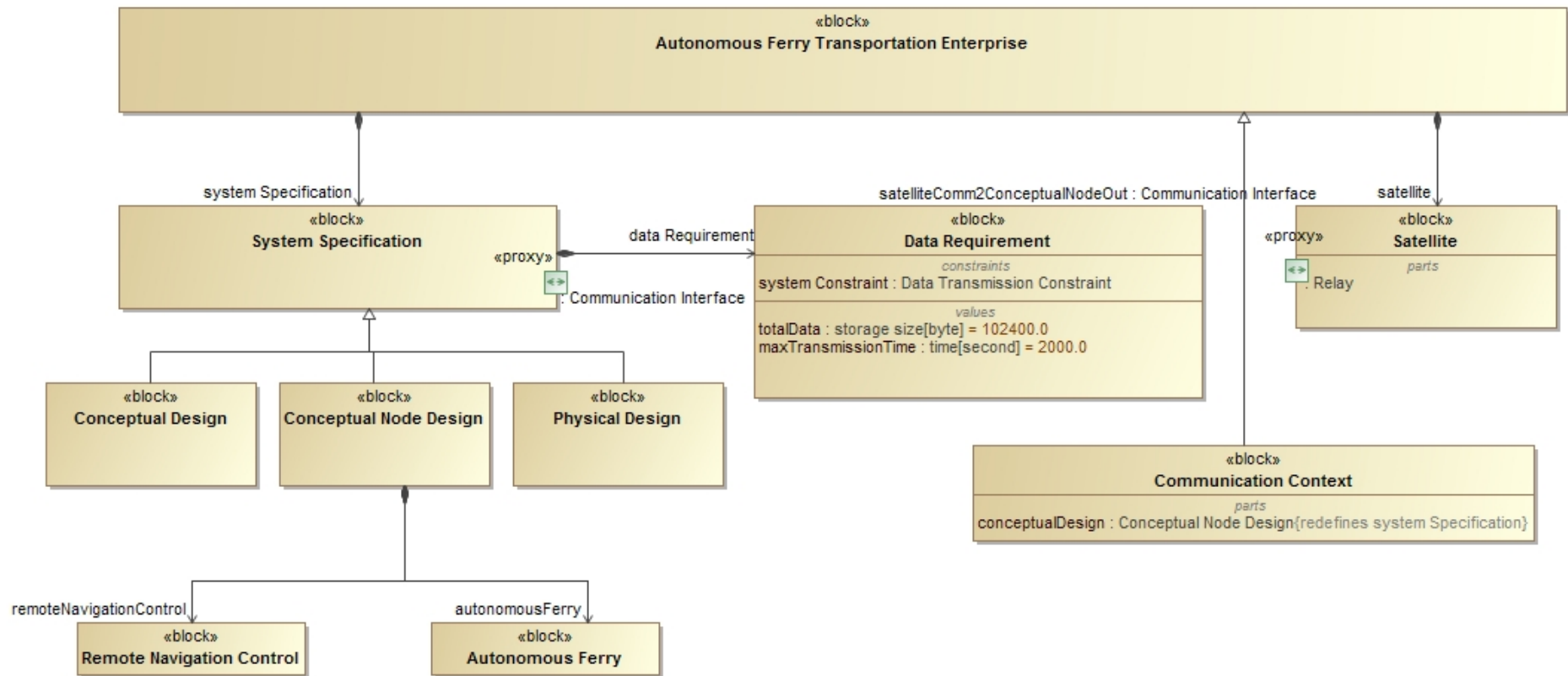


Analysis Context

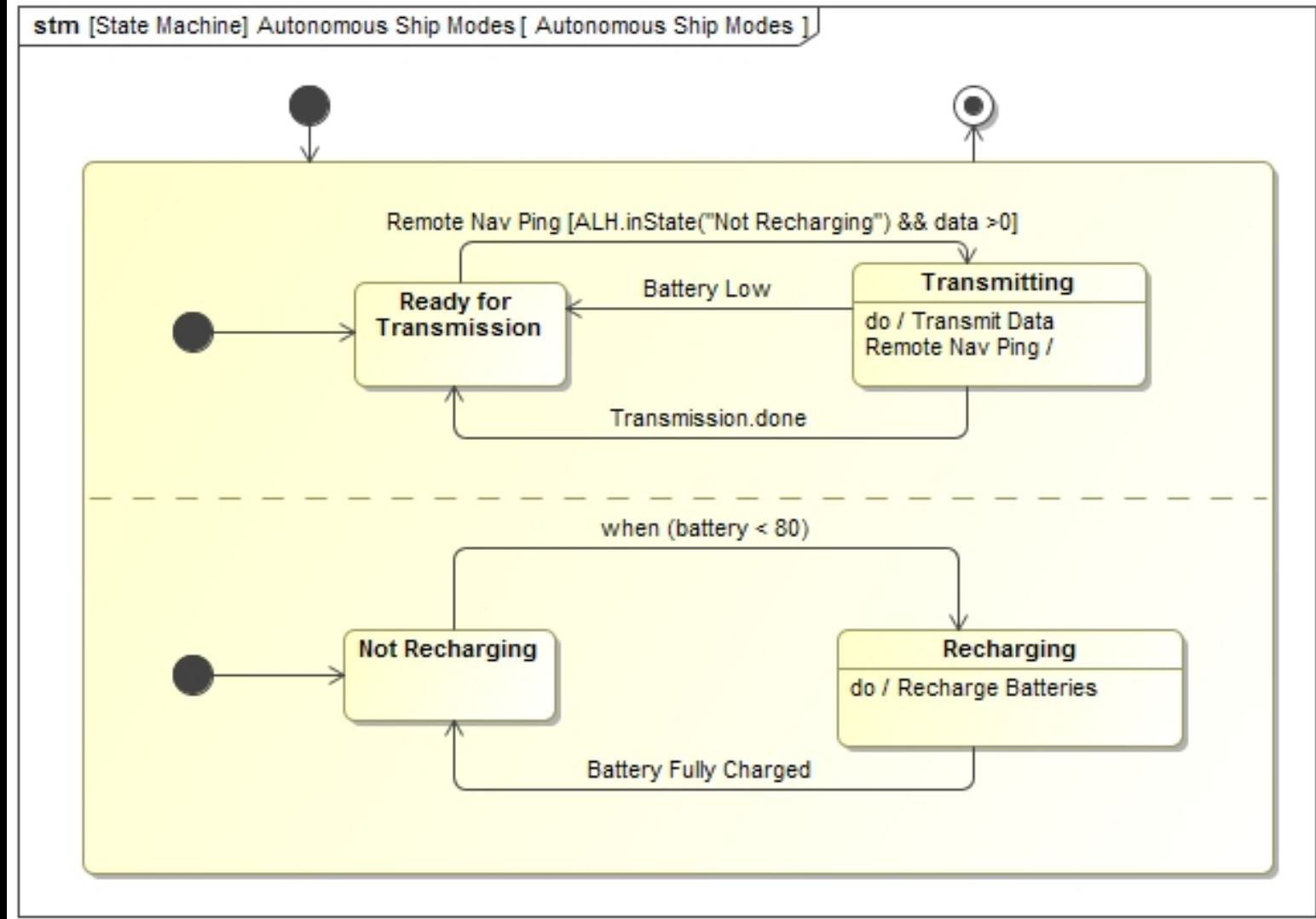


Context Educational Example

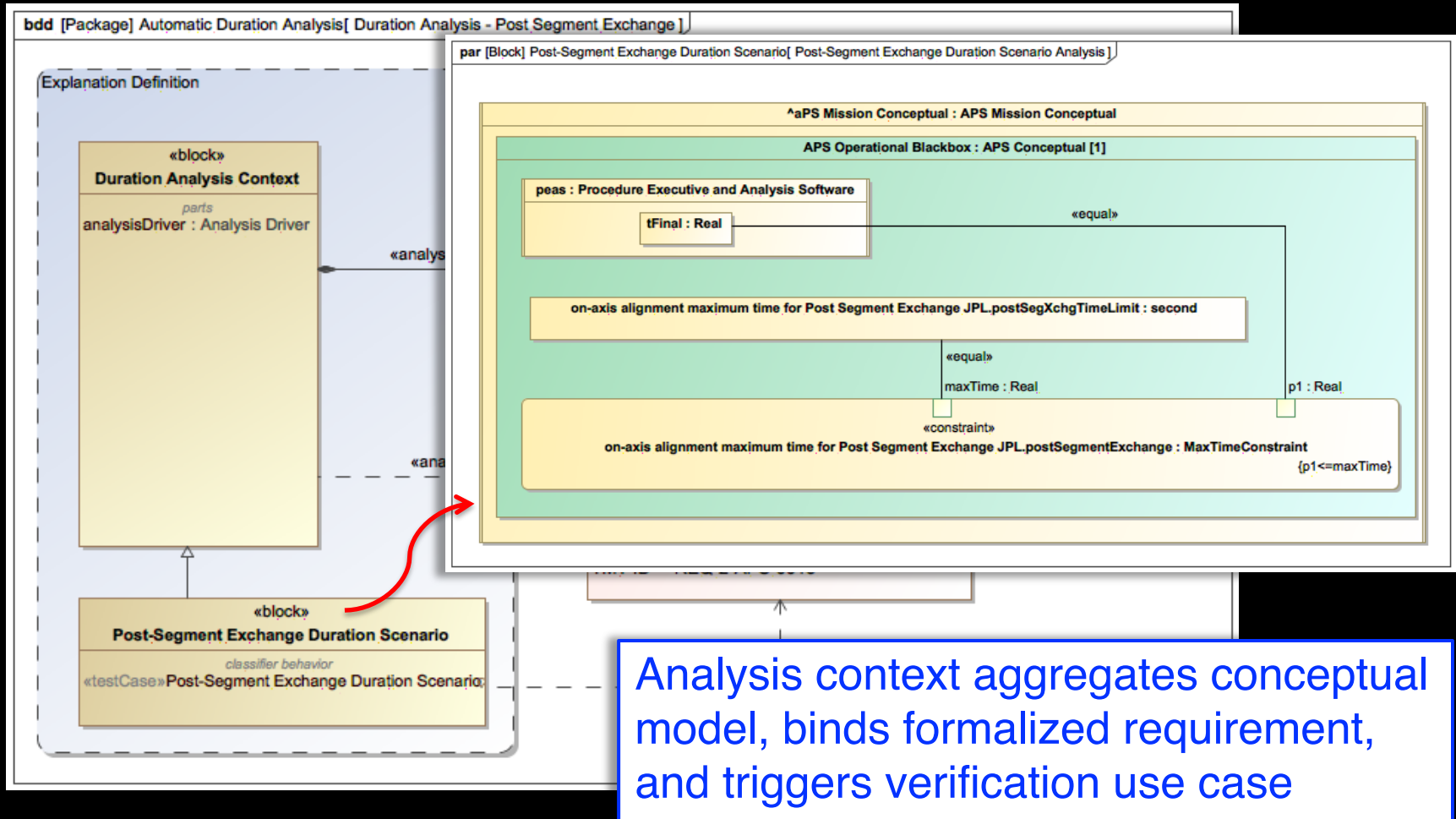
bdd [Package] Structure [ Structural Decomposition]



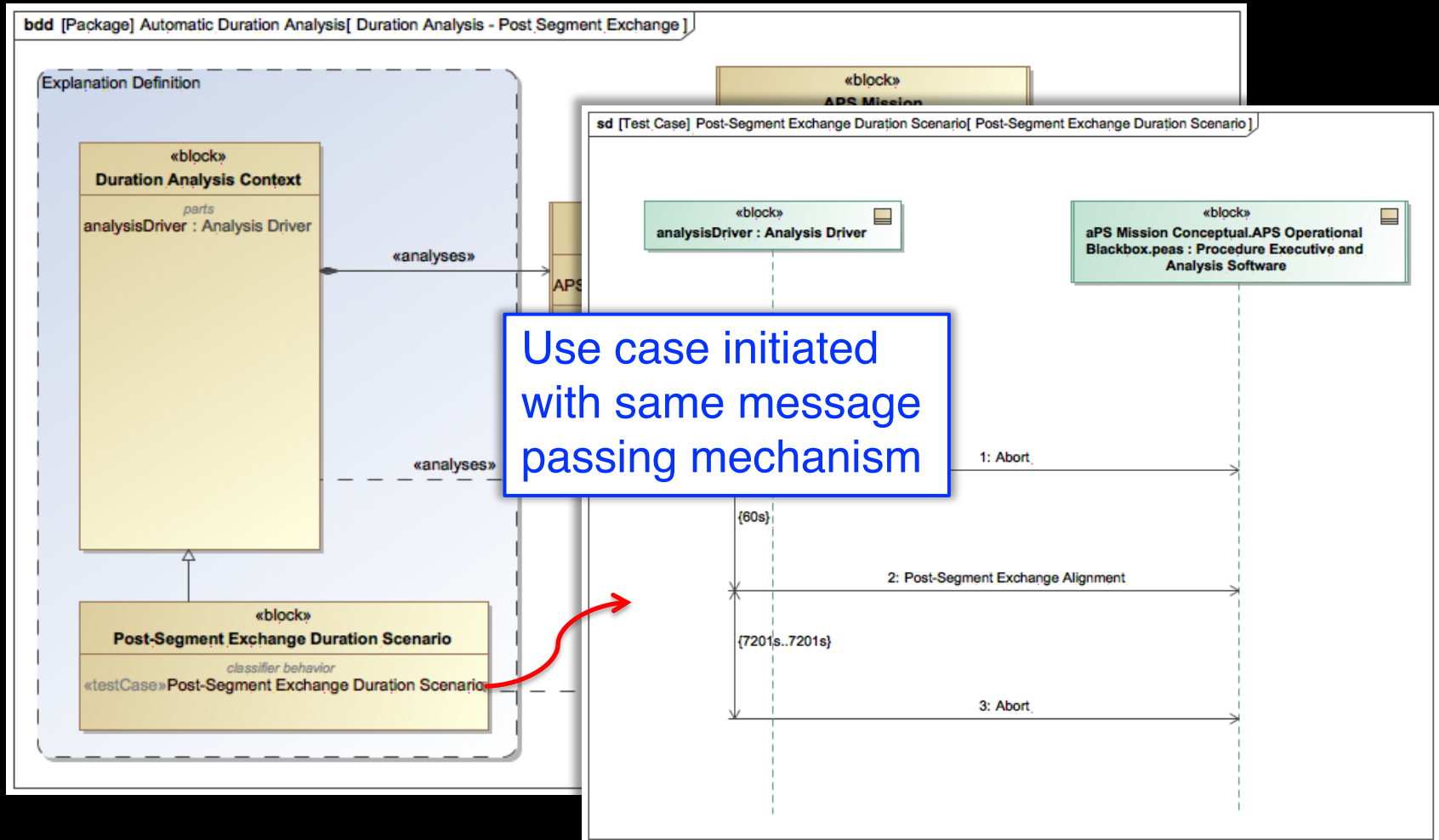
Behavior Ship



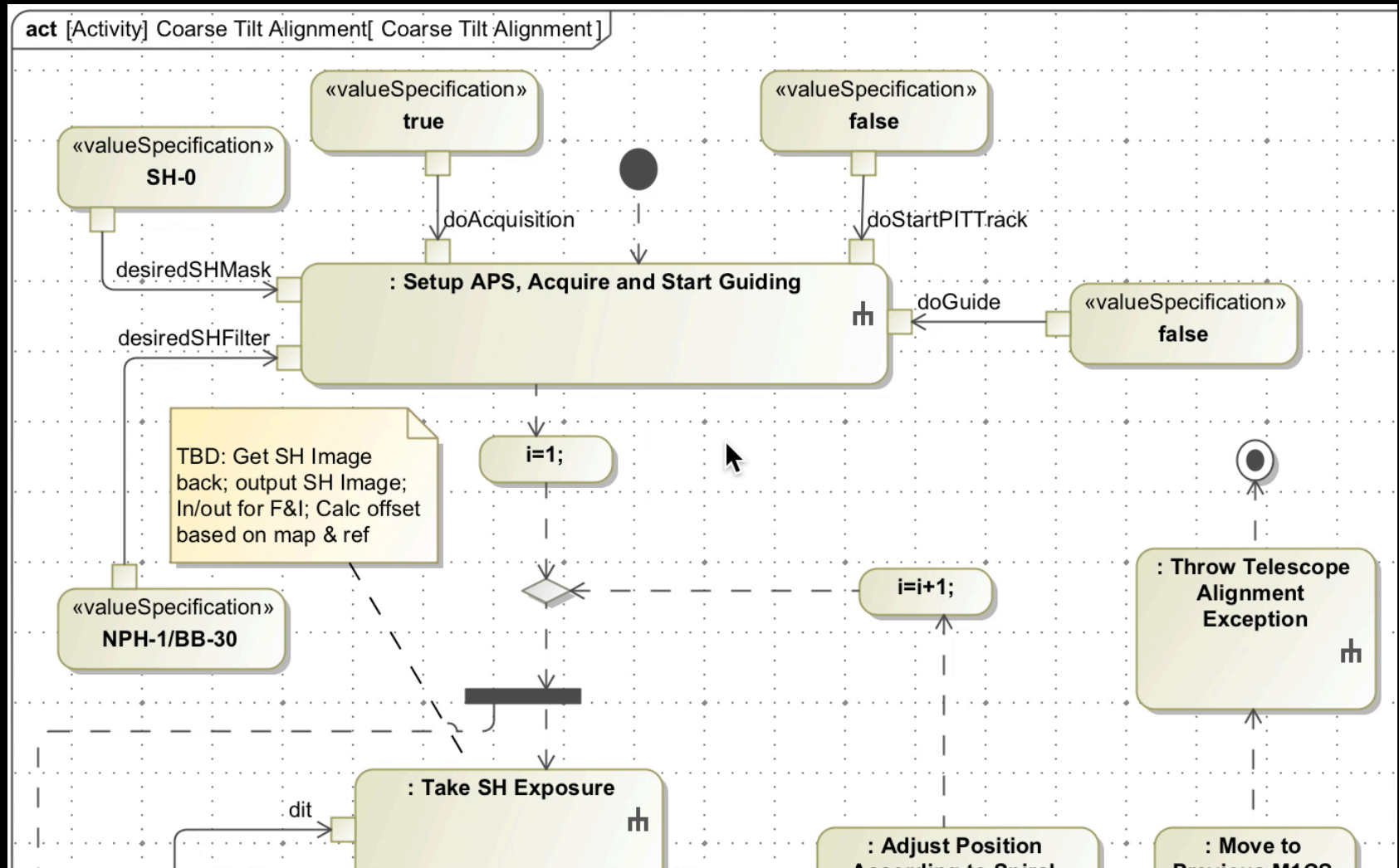
Verifying Timing Requirements by Simulation



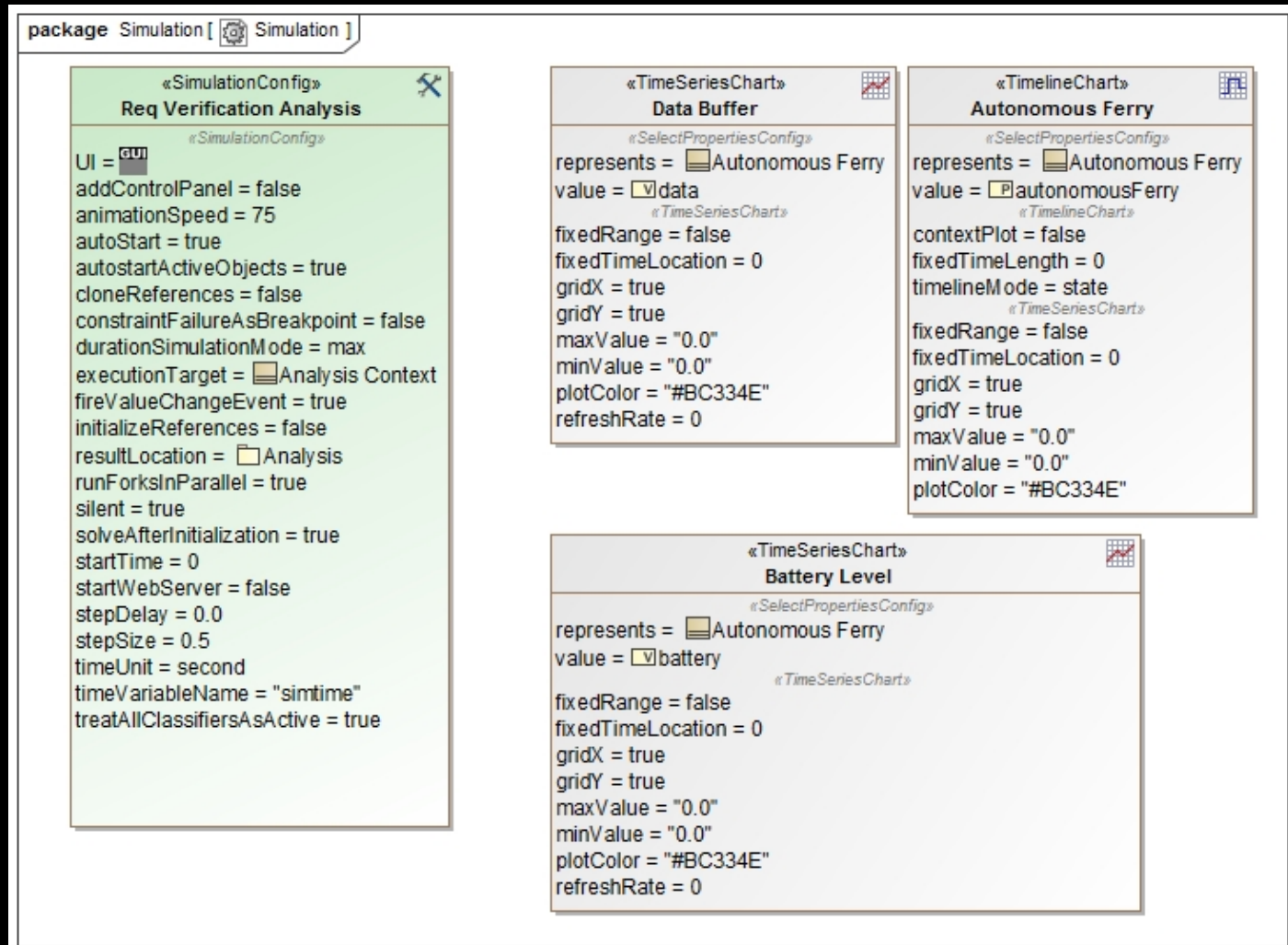
Verifying Timing Requirements by Simulation



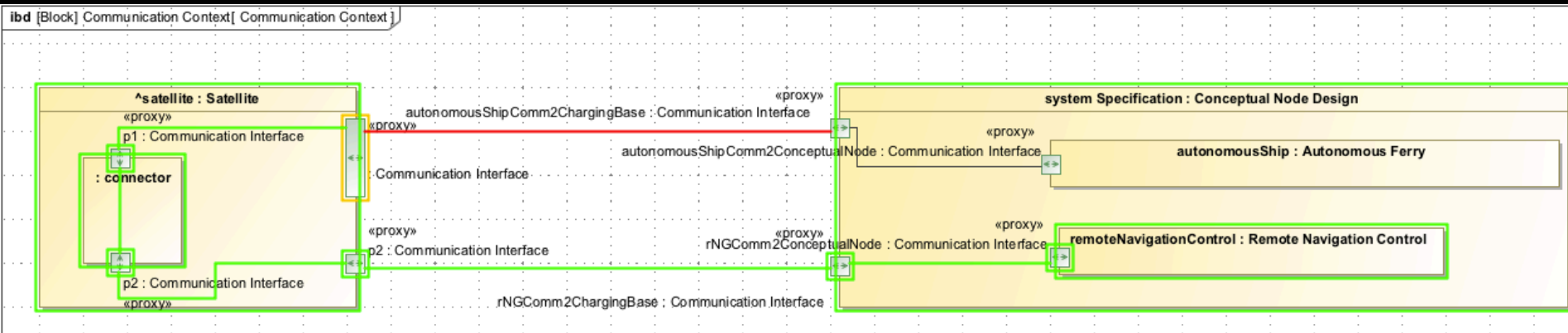
Verifying Timing Requirements by Simulation



Simulation Configuration with Cameo



Executing a scenario



Simulation Run

Simulation interface showing the current state of the simulation.

Trigger: [Dropdown menu] **Animation speed:** [Slider]

Sessions:

- Analysis Context [Analysis Context@3e30001d] (Paused)
- Operational Scenario [Analysis Context@3e30001d] (Paused)
- Autonomous Ship Modes(classifier behavior) [Autonomous Ferry@15f813a8] (Paused)
- Remote Navigation Control(classifier behavior) [Remote Navigation Control@1b98291b] (Started)
- Transmit Data [Autonomous Ferry@15f813a8] (Paused)
- Transmit Data [Autonomous Ferry@15f813a8] (Paused)
- Receive Data [Remote Navigation Control@1b98291b] (Paused)
- Receive Data [Remote Navigation Control@1b98291b] (Paused)

Variables:

Name	Value
Analysis Context	Analysis Context@3e30001d
mission : Communication Context	Communication Context@7f94c337
satellite : Satellite	Satellite@5deb685b
connector	connector@5710aad8
system Specification : Conceptual Node Design	Conceptual Node Design@70c22cdc
autonomousFerry : Autonomous Ferry [, Not Recharging, Transmitting]	Autonomous Ferry@15f813a8
battery : Real	100.0000
data : storage size[byte]	1.0240E5
t0 : time[second]	23.7920
tfinal : Real	0.0000
transmissionInProgress : Boolean	<input checked="" type="checkbox"/> true
data Requirement : Data Requirement	Data Requirement@56fe571e
maxTransmissionTime : time[second]	300.0000
totalData : storage size[byte]	1.0240E5
system Constraint : Data Transmission Constraint (maxTransmissionTime...)	Data Transmission Constraint@375b3c11
designTime : time[second]	0.0000
maxTime : time[second]	300.0000
remoteNavigationControl : Remote Navigation Control [Operation]	Remote Navigation Control@1b98291b

Analysis by Simulation

